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An Assessment of Technology Adoptability in Sugarcane Burning Smoke Plume Mitigation

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DEDICATION

To my family – Dad, Mom, Michael, Jill, Luke, Missy, Dominic, and Baby E. You are my first teachers, my best friends, and my greatest supporters and I am so grateful to have you as my family.

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ABSTRACT

The adverse health effects of sugarcane burning emissions on surrounding communities are well documented. Sugarcane farmers in Louisiana, a major sugarcane producing state with 385,000 acres dedicated to sugarcane farming throughout, attempt to mitigate the effects of burn emissions by estimating the characteristics of the resultant smoke plume using meteorological variables as parameters. The current mitigation method designed by the Louisiana State University (LSU) AgCenter, the American Sugar Cane League, and the Louisiana Department of Agriculture and Forestry is a manual process requiring the tedious look-up of atmospheric variables from multiple sources and physically drawing a predicted smoke plume on a paper map, leaving room for human error. Because of the manual properties of this process and similar processes in other sugarcane producing states, the questions arise – why is technology not being utilized to improve it? And if the appropriate technology did exist, would they want to use it? Previous agriculture technology adoption research focused mostly on the adoption of precision agriculture techniques and the computer/Internet. However, the question is shifting from - do farmers own a computer/Internet? To - how are they using it and what motivates them to use certain applications? Therefore, the focus of this study is the adoptability of a new online burn emission application developed to replace the manual mitigation process. The survey assessed which characteristics of Louisiana sugarcane farmers and farms are related to the adoptability of the new application. The survey questions asked for demographic information, behaviors and attitudes related to

technology, and behaviors and attitudes related to their community, including their level of participation in the currently used manual mitigation program. The correlations found between these variables and the likelihood of adopting the new online application provide insight into what drives a farmer to use technological tools such as this burn emission application and if this is an industry space that would welcome similar applications. Variables measuring technology use and perception were most frequently correlated to the adoption of the application, community variables were somewhat correlated, and demographic variables were not significantly related while overall the application is likely to be adopted.

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CHAPTER 1

INTRODUCTION

1.1 Research Goals and Contributions

The uptake of information technologies in the agriculture sector has lagged in comparison to other small and medium-sized businesses (Warren, 2004) and compared to non-agriculture business in general (Hagar and Haythornthwaite, 2005). Adoptability is slow in comparison because of the variability in the industry – spatial, temporal, climatic, and geographic – in addition to the lack of people trained in both information technologies and agriculture systems to develop appropriate applications and tools (Steward, 2012). In contrast to other businesses, technology adoption decisions in agriculture are more likely related to the characteristics of one or a few individuals who manage the farm and make decisions based on their personal technology preferences and not the characteristics of their business (Gloy and Akridge, 2000). These personal characteristics have been well-studied in consideration of computer and Internet adoption but with computer and Internet accessibility steadily increasing among this population it is becoming a less often researched area. The new research trend is to study the frequency with which farmers are using the computer/Internet, what they are using it for, and what makes them more likely to utilize it. The greatest barrier to Internet adoption in agriculture businesses today is farmers not understanding how it can benefit their business, surpassing the previously largest barrier of lacking technical expertise (Burke, 2010; Gelb and Voet, 2009). Farmers know *how* to use the Internet, but they don't see *why* they should use it. By studying their use and perception of technology, tools and applications built for use in the agricultural sector can be tailored to the preferences of the farmer/user to better support their decisions.

Sugarcane burning is a necessary industry practice but has adverse health effects on neighboring communities (Arbex et al., 2007; Cançado et al., 2006; "Prescribed burning background," 1992; Mazzoli-Rocha et al., 2008). Each of the four sugarcane growing U.S. states, Florida, Texas, Hawaii, and Louisiana, has a smoke mitigation program in compliance with the federal mandates of the USDA Agricultural Air Quality Task Force (AAQTF). Participation in the smoke mitigation programs is mandatory in all states except for Louisiana, where it is highly recommended but remains voluntary, accentuating the need for an easy process and helpful tools as any obstacle can overturn a farmer's desire to participate. This thesis introduces a new online application for sugarcane farmers in Louisiana called the Sugarcane Burn Planner, designed to replicate their current paper mitigation process in digital form. To evaluate this newly developed system through an online survey, farmers were asked to rate how likely they are to use the planner, how easy-to-use they find it, and how useful they find its features. These measures of adoption were compared to their demographic information, technological experience and perception, and community measures of involvement in the Louisiana smoke mitigation program and geographic awareness of who their burns could potentially affect. This analysis was then compared to past studies of computer/Internet adoption to see if any patterns they found hold true. In regards to technology adoption in agriculture literature, this study uniquely compares adoption to the previously explained community measures since mitigating sugarcane burning smoke and ash is an inherently geographic issue, introducing an interesting geographic variable. Also, since the application is almost an exact digital replication of the steps in the paper-based smoke mitigation program, this research will determine if the application, which does not necessarily generate new knowledge, is likely to be adopted simply because it makes the process easier and faster.

The research contributions of this thesis extend outside the technology adoption question. Practically speaking, the Sugarcane Burn Planner is now publicly available and has been transitioned to the LSU AgCenter to distribute to their network to make the burn plan process easier for farmers. Also, the survey conducted following the Sugarcane Burn Planner development asks questions about the Louisiana mitigation program, providing the program's first official evaluation since its inception in 2000, measuring the effectiveness of their outreach program. The initial idea to develop the Sugarcane Burn Planner came out of a separate research extension plan of a larger study, making this thesis a validation tool measuring the effectiveness of that outreach effort as well. Debates often take place about the appropriate level of funding for outreach and extension efforts and by assessing the current program and gauging constituent demand for new technology, funding allocation decisions can be better supported. And, finally, the results from this study indicate if an opportunity for other similar applications to be developed is present in this industry space.

1.2 Research Questions

The question of computer and Internet adoption in U.S. agriculture is becoming less pertinent as computer ownership and Internet access are increasingly commonplace and rurality is no longer considered an adoption barrier (Zickuhr & Smith, 2012; Briggeman, 2010). Taragola & Van Lierde (2010) redefine the important research question of *which*

Internet applications are being used in agriculture and *what* farm and/or farmer characteristics influence this decision. This thesis follows the new research trend by narrowing the computer/Internet adoption in the agriculture question to the adoptability of one online application designed for use by the sugarcane farmer community of Louisiana. The following research questions guide this thesis:

1. What demographic, community, and technology characteristics are related to the perceived usefulness, usability and adoptability of the introduced online application and how does it compare to patterns shown in the literature as related to computer/Internet adoption?

2. Do any other relationships exist between the demographic, technology, and community variables?

3. Even though the introduced application would presumable be useful in sugarcane burning smoke mitigation, would it actually be used? Is there an opportunity for similar tools to be developed in this industry space?

CHAPTER 2

LITERATURE REVIEW

2.1 Farm and Farmer Characteristics Related to Adoption

Studying farm and farmer characteristics helps explain why technology adoption rates are consistently lower in the agriculture sector, and in turn provides context to how they can be raised. For example, if older farmers with more farming experience are less likely to adopt a useful farm management technology, outreach resources can be directed to this particular group to advocate for adoption by addressing their specific concerns or obstacles. If formal education is an indicator of adoption potential but extension program participation is found to be an adequate substitute for formal education, the argument for extension program support funding is reinforced. By understanding what demographic characteristics are related to technology adoption and extension efforts, applications tools can be fashioned to better address the diversity of the population they hope to serve. An assessment of current technology perceptions and use defines the end user's demand and expectations of technology. Reviewing how these characteristics influenced adoption in past studies, hypotheses can be formulated about how they will or will not influence the adoption of the Sugarcane Burn Planner. The results of this study will contribute to the on-going agriculture technology adoption story as computer and Internet ownership and use steadily increase over time.

Age. One of the most consistently studied farmer characteristic in relation to technological adoption is age. It is fairly agreed upon that a negative association exists, where increased farmer age is associated with the decreased use of Information and Communication Technologies (ICT) (Ferrer, Schroder, and Ortmann, 2003; Warren, 2004; Gloy and Akridge, 2000; Mishra, Williams, and Detre, 2009; Taragola and Van Lierde, 2010), although the explanations in the literature for why this association exists vary slightly. The relationship between age and technology adoption is often explained by a 'bridging' variable related to age such as ICT exposure, planning timelines, and farming experience.

Taragola and Van Lierde (2010) theorize that because older farmers are less familiar with some technologies, specifically Internet applications, they trust it less and do not utilize it as a tool for their business as frequently as younger farmers. The basis of this argument is that older farmers are not as exposed to newer technologies or the Internet whereas younger farmers may have used such tools during school or for socialization and have increased exposure and, ergo, increased trust. Ferrer et al. (2003) agree with this line of logic, also recognizing that technology familiarity in the form of computer/Internet exposure is connected to increased trust in the information provided by such resources. Planning timelines affect the farmers' decision to adopt certain technologies because older farmers operate with a shorter timeline in mind since they will reach retirement age sooner. For those nearing retirement, the time and effort required by the adoption of a certain technology can outweigh the potential benefits of adoption because fewer years working means less time to see productivity dividends. This is in contrast to younger farmers with much longer timelines who are more apt to expend the effort needed to acquire the new skills or knowledge for the adoption of new technology ("Publicly funded agricultural," 2002), because they have more time to reap the benefits of their time or monetary investments (Ferrer et al., 2003). Another common 'bridging variable' between age and technology adoption is farming experience, as older farmers often have more experience. Schnitkey, Batte, and Jones (1992) confirmed the strong relationship between age and farming experience and found that those with more farming experience are less likely to look for external information to aid their decisions than those with less experience. Ferrer et al. (2003) agree with this statement in the context of Internet use. They found that older farmers with more farming experience value the information that can be attained from the Internet far less in comparison to younger farmers with less experience. But this is not a relationship that is unanimously agreed upon in the literature. For instance, Ford and Babb (1989) found the opposite to be true – that farmers with greater experience sought out the information provided by extension services more so than younger farmers because they understand the value of up-to-date information from a diverse set of sources.

Farming Experience. Age has been used as a proxy for farm experience (Lewis, 1998) and farming experience has been used to replace farmer's age (Hoag, Ascough, and Frasier, 1999). An obvious relationship exists between these variables so it is not surprising when surveyed farmers with more farming experience are less likely to adopt ICT, similar to older farmers. But farming experience has been found to be positively (Ford and Babb, 1989) *and* negatively (Schnitkey et al., 1992) related to those who seek out knowledge from extension services, and continuing down the chain of effect, those seeking extension services were found to be more likely to adopt ICT (Huffman and

Miranowski, 1981). To take the analysis of farming experience and ICT adoption to the next level, more recent literature has explored farmers' intuition, which is seen as a byproduct of farming experience.

A farmer's judgment and decision-making process is referred to by McCown (2012) as a "black box" cognitive model which Öhlmér (2007) splits into two methodological categories of thought: Intuitive and Analytical. Intuition is a result of farming experience, built up as processes are repeated throughout a farmer's years of experience. He or she develops a "sense" about how to make a decision without using quantitative data analyzed in a step-by-step process. Instead, they can make a decision by looking at the magnitude of a problem as a whole and by using qualitative information such as word of mouth or the way something looks and feels. Öhlmér (2007) found that all of the farmers he interviewed *prefer* intuitive information, including farmers who regularly use more analytical methods. Car, Christen, Hombuckle, and Moore (2012) interviewed irrigators in Australia on their use of a full irrigation scheduling Decision Support System (DSS) that has the proven ability to increase water user efficiency but has shown low adoption rates. Their study also found that most irrigators relied on their intuition, ultimately based on personal vine observations, weather observations, and experience, and even those irrigators who did utilize the DSS did so in conjunction with the same intuitive information. Alvarez and Nuthall (2006) had a similar finding but discussed it in terms of learning style. By surveying communities of dairy farmers in New Zealand and Uruguay, he discovered that the farmers that were less likely to use relevant software products tend to have a "reflective observation or abstract conceptualization" learning style, more compatible with an intuitive thought process, in contrast to a “concrete experience or active experimentation” style, more apt for analytical methods.

Considering these previous studies, McCown (2012) has recently introduced a cognitive systems framework that attempts to bridge the gap between intuitive and analytic practices with the goal being to combine external information with the farmers’ internal system of practical knowledge and learning. An example of a well-received bridging practice in the farmer test group was based on ‘if-then action rules’. The foundation of the rules for this example were built using analytical methodology with graphical comparisons of conditional probability distributions of simulated yield scenarios for a variety of weather conditions. Then, appropriate actions were related to each of the scenarios. As the rules dictating the appropriate actions were repeatedly used, they became a ‘prior expectation’ of the farmer, which contributes to his or her intuitive senses and preferred decision-making manner although fundamentally based on quantitative analysis.

Education. In addition to age, education is also a common variable used to help explain how likely a farmer is to adopt a piece of technology. Batte (2005) found the presence of post-high school education to have the most influence on the likelihood of farm computer adoption, with a 30.86% point increase over those without a post-high school education, and is supported by many other researchers who have also found education to be positively related to the adoption of technology in agriculture (Ferrer et al., 2003; Gloy and Akridge, 2000; Mishra et al., 2009; Mishra and Park, 2005). There are a few explanations for why this relationship exists, the most obvious being that farmers with more education are exposed to and have more experience with the Internet and computers, making them more likely to adopt these technologies in their businesses (Ferrer et al., 2003). Öhlmér (2007) delves deeper into how farmers' formal education impacts the way they are trained to think. Computers and related ICT technologies produce quantitative information aimed for analytical thinking and those with more formal education have been trained to think in a way that fits this paradigm. Farmers with higher education levels have not only adopted computerized management tools more but are also the ones who find them more useful because they operate in the quantitative manner their brains were taught to think.

Researchers, such as the authors of "Publicly funded agricultural" (2002) and Taragola and Van Lierde (2010), have expanded the education/technology adoption topic by putting formal education into a broader category of intellectual capabilities. "Publicly funded agricultural" (2002) names one category, Allocative Ability, that includes education level, intellectual skills, and aptitude for learning and assessing new technologies. This inclusiveness recognizes that some farmers without formal education can, of course, still have high intellectual capacity and may be more likely to adopt ICT than those with lower learning capacities. Taragola and Van Lierde (2010) refer to a comparable category called Communication Behavior, which is defined by how much farmers seek out information. The idea or expectation is that socially open farm managers (a characteristic which may or may not be the effect of formal education) are more likely to seek out agriculture extension services, seminars etc. and are thus more likely to adopt value-adding Internet applications they introduce. Through the introduction of the Communication Behavior category, Taragola and Van Lierde (2010) have brought up an interesting point about whether or not agriculture extension services can act as a proxy for formal education when it comes to technology exposure and adoption.

Farm Size. After age and education, farm size is the most commonly studied variable in agriculture ICT adoption and is typically found to be positively related (Putler and Zilberman, 1988; Amponsah, 1995; Gloy and Akridge, 2000; Mishra and Park, 2005; Warren, 2004). The general premise is that farm size captures the scale of operation effect on computer and software adoption since technological investment and adoption costs are cheaper when spread over increased units of output on larger farms, making the likelihood of ICT adoption higher when compared to smaller farms (Mishra et al., 2009). Batte (2005) measured this relationship in terms of annual farm gross sales – with a $1000 increase being associated with a 0.07% point increase in the likelihood of computer adoption. The adoption of the Internet, which has a much lower adoption cost than its computer prerequisite, has also been found to have a positive relationship with farm size although it is statistically weak (Gloy and Akridge, 2000). The study conducted by Huffman and Mercier (1991) of Iowa farmers between 1982 and 1984 was among the few studies that did *not* find farm size to be significant to adoption rates, but they did find a significant relationship with their farming complexity variable, which incorporates farm size and type of farming activity. This is supported by Mishra and Park's (2005) findings of a positive and significant adoption relationship with an increased diversity of crop production. Unlike many studies who examined the relationship of computer and Internet adoption with farm characteristics, Larson et al. (2008) looked at cotton farmers' likelihood to adopt remote sensing imagery, but they also found adoption to be positively related to farm size.

Technology. The possession of different technologies, such as a desktop computer, laptop, or smartphone, and how they are used to support farm management or other non-related purposes impact a farmer's decision to adopt additional technologies. The possession and use of a laptop and/or smartphone in the field made farmers 2.1 times more likely to adopt remote sensing imagery than farmers who did not, according to Larson et al.'s (2008) study. Using these Internet-accessible devices in off-farm, non-related work or managing away from the farm year-round due to outside employment makes an individual more likely to adopt new technology (Batte, 2005). The introduction of certain technologies through outside employment often acts as a catalyst – providing the technical skills and inspiring the farmer to ask: "how could this technology benefit my farm management and business?"

Another common catalyst of adoption and use is the utilization of technology in the farmer's home for purposes unrelated to the farm business by either the farmer or the farmer's family. Using the 2004 Agricultural Resource Management Survey (ARMS) survey data, Mishra et al. (2009) looked specifically at the influence of farm household characteristics, like the presence of a spouse and children, and found them to increase the likelihood of a farmer to adopt the Internet. Their overall conclusion stated that the majority of the 67% of farm households that have a computer with Internet access were young, college-educated, married farmers with teenage children. Harkin (2005) suggests the inclusion of *how* all the members of the family uses the Internet as a factor of adoption, such as using it to book travel or to complete children's homework. This may be a more impactful factor than previously thought, as Smith, Morrison Paul, Goe, and Kenney (2004) found exposure by college, outside employment, friends and family to be more influential variables than the time-tested variables of age and farm size in his 2001 survey of Great Plain farmers.

As the presence and use of social technologies increases across all demographics, the use of the computer and Internet for social and entertainment activities by farmers is another factor more recently being analyzed. Warren's (2004) survey of UK agricultural businesses found that the use of the computer and Internet for these purposes can be an effective teaching tool and act as a springboard to business use. However, a study of SME agribusinesses in Hawaii concluded that, with the exception of email, the extent of social technology adoption is relatively minimal with 47% of respondents indicating that they use *none* of the following social technologies: email, online discussion forums, blogs, podcasts, wikis, chat, and instant messaging. So, although it may act as an effective teaching tool, farmers use the computer and Internet for socialization and entertainment less than average.

Other Socioeconomic Factors. Age, education, farm size, farm experience, and existing possession and use of technology rightfully have a high frequency of focus due to their repeatedly cited influence of ICT adoption in agriculture, but they are not the only socioeconomic factors that have been studied. Briggeman (2010) uniquely focused on the socioeconomic factors of the *non-user* of the Internet instead of accepting the dichotomous assumptions of previous studies. His contribution was the surprising result that living in a more rural area is *not* a significant factor for farms not using the Internet. The amount and extent of general planning was a factor used in the study of Gloy and Akridge (2000), supporting a positive relationship between the use of a written business plan and PC adoption as well as a positive relationship between an increase in the intensity of farm planning and Internet adoption. Mishra and Park (2005) reported that the type and diversity of crop production is positively and significantly related to ICT adoption and use. It is important to note that there have been a number of studies throughout the adoption literature, such as these discussed, that uniquely introduce a new factor of influence found to be statistically significantly related to adoption patterns. The implication is to be wary of what factors are left out of a study and how they may be unduly accounted for in another variable.

2.2 Internet Adoption

An individual's perceptions and attitudes toward technology drive their behavior and their likelihood to adopt technology. More specifically, the personal attitude of farm business managers of ICT usage in agriculture is crucial to adoption, supporting the overall theory that the study and development of human capital is important to raise adoption rates (Taragola, 2010). Farmers' attitudes about what benefits a computer can provide have shifted. Previously, the general perception was that using a computer is most beneficial as a cost minimization tool and it is now seen as more useful for farm management and production (Michailidis, 2006). Attitudes toward the Internet do not necessarily mirror attitudes toward the use of computers because, although a computer is virtually necessary to use the Internet, there are many characteristics that differentiate the Internet from PC usage and it is constructive to examine the adoption of the two separately (Taragola, 2010).

On the subject of the perceived usefulness of the Internet for agricultural business, the literature has found patterns of both high and low farmer-perceived value– an inconsistency most likely attributed to the wide spectrum of sampled farmer populations through time and geographic location. Ferrer et al.'s (2003) study surveyed sugarcane farmers in the KwaZulu-Natal Midlands of South Africa who, despite having very high incidences of Internet connectivity, generally did not think the Internet was a useful information source and very few reported a reduced reliance on other information because of having an Internet connection. A similar study conducted in the UK by Warren (2004) found that farmers did not believe the Internet was an important part of their business. Only 22% of respondents, who were surveyed in both 1996 and 2001, believed that their business changed due to the influence of the Internet but not in any dramatic way. It is important to note that these studies were not based in the U.S. and were each conducted over a decade ago, which may make their findings less relevant in today's context when considering the very high growth rate of Internet usage within the last 10 years as well as the increase of Internet connectivity speed and Internet-based tools.

In a more recent study by Batte (2005) surveying farmers in Ohio, the 3 highest ranked computer uses that farmer's stated improved their business were keeping financial records, email, and keeping production records – two of which can still be done without Internet access. Those who indicated an above average computer usefulness evaluation predictively used the computer most for financial or production recordkeeping, but also were more likely to use the Internet for gathering information. About 73% of responders identified "Internet-based applications" as one of the most ubiquitous computer tasks, indicating the growing importance of the use of the Internet as a tool in farm management.

A study in Greece conducted by Michailidis (2006) quantified farmers' perceived usefulness of the Internet by separating out the usefulness of specific Internet applications. The highest values were given to the lookup of technical information, electronic banking, and social and recreational uses. Interestingly, the farmers who indicated that they use the Internet primarily for consulting market prices and weather forecasts were also the ones most likely to assign a general low value to Internet usage. This may indicate that the Internet is not useful in directly replacing the same information that can be found elsewhere and, in order to be perceived as useful, needs to make something more efficient, faster, or provide new information or services. The trend shows that the perception of the Internet as a tool in agricultural management is becoming more favorable as time goes on, but is not believed to be nearly as crucial as it is in other small to medium sized businesses today.

2.3 Obstacles to Adoption

Once the slow rate of ICT adoption in agriculture was recognized, studies have hypothesized and concluded a number of different reasons to explain this pattern. The most agreed upon explanations include farmers not perceiving a benefit to using the computer and/or Internet, the farmers' primary job involving manual labor, the overwhelming amount of agricultural data that exists, and the generalized nature of many agriculture sector applications.

Recent studies have agreed that a shift in technology adoption barriers from farmers not having the technical knowledge to farmers not seeing the benefit of using the technology has occurred. Burke (2010) found that of the 20% of farmers surveyed who do not use the Internet, 8% "do not see the benefit", 4% "lack the appropriate infrastructure", 4% "have not really thought about it", and 2% "lack the technical knowledge". This is supported by a larger scale study conducted by Gelb and Voet (2009), who surveyed IT professionals at an international conference and confidently concluded that the inability of farmers to use ICT has essentially been overcome. There are many cases where the technology has proven benefits but have been poorly adopted, so why is the benefit not seen by the farmers? Öhlmér (2007) hypothesizes an educational constraint that affects the farmers ability to understand the information content provided by the technology, which Gelb and Voet (2009) believe is due to public training services continually lagging behind the latest ICT developments. Other explanations include the following: ICT analytical tools aimed to support a repetitive process are often managed with farmers' intuition alone (Öhlmér, 2007), poor usability of the new technology (Alvarez and Nuthall, 2006), failure of the developers to address the real problem (Alvarez and Nuthall, 2006) and a farmer's unfamiliarity with how to apply the ICT to their specific uses (Briggeman, 2010).

Even if a farmer understands the potential benefits of technology, specifically the Internet, they may not sit in front of a computer as often as those in primarily office-based professions. The primary farm manager usually has the split duties of managerial tasks and manual labor in the field, an important differentiating factor when compared to managers of other SME businesses that perform the majority if not all of their tasks in an office setting using a computer. A study by Warren (2002) points to this as the most significant roadblock to ICT usage because after a farmer fills his or her day with a long, hard schedule of manual work, the proposition to stare at a computer screen is far from attractive. Gloy and Akridge (2000) statistically found this relationship as well with their variable of manager participation in farm physical labor being negatively related to computer and Internet adoption. On a related note, Alvarez and Nuthall (2006) hypothesizes further that farmers prefer physical work relative to spending time in an office and as a result this cuts down on their time dedicated to computer and Internet usage. If there is an alternative method, such as sitting with a piece of paper instead of being in front of a screen, it may be the preferred option due to the "ease of reading paper-based communication at the kitchen table or in the living room" (Warren, 2004). A recent study of Louisiana farmers' information dissemination preferences concluded that interpersonal communication is still the primary means of communication with individuals engaged in agriculture and is the preferred method overall among Louisiana crop producers and consultants, implying an aversion to "screen-based" communication (Gautreaux, 2011).

With more digital sensors and Internet collaboration than ever before, agriculture has become a data intensive industry. This is a positive development but the benefits cannot be realized without adequate management and presentation of the data, as sifting through the wealth of data to find what is relevant can be a daunting task for a farmer – especially when the data originates from many sources and is received in a variety of different formats (Sorensen et al., 2010; Ferrer et al., 2003). Couple these problems with the issue of compatibility with their existing devices and the burden is enough to prevent some farmers from even attempting the information search (Csótó, 2010). The magnitude of information that exists was an agreed upon problem in an international workshop of professionals, involved in Internet and Information Technology in agriculture in their respective countries, demonstrating the universality of the problem. All workshop participants completed a survey about the role of the Internet in agriculture and the highest rated drawback from using Internet for extension services was “Too much (possibly contradicting and/or non-focused) information” (Gelb and Bonati, 1997, p.6). Service providers should determine the users’ needs before developing information portals or disseminating agricultural data because much of what currently exists is non-homogenous and overwhelming.

Data problems can manifest in scale as well as size. Generalization of information is often highlighted as an obstacle of ICT adoption in the agricultural sector. Agriculture differs from other SME businesses because a farm is often managed by one or a few individuals who have their own ideas about what information they need and their own preferences concerning how to obtain it. Gloy and Akridge (2000) point out that, overall, the literature less consistently finds a relationship between adoption and business characteristics when compared to that between adoption and personal characteristics of farm mangers. It is the demand for information by the farmer and not the demand for information by the business that motivates the adoption of new technologies, putting the personalized preferences and individual socioeconomic characteristics of the farmer at the forefront of many studies (Amponsah, 1995). Since each farmer is different and has his or her own information strategy, developing IT that coincides with all of their preferred patterns of operation is very difficult (Csótó, 2010). Much of the agricultural data that exists today is generalized and the relevant and specific knowledge that is more valuable to the individual farmer is not made into a consumable form that is easy to understand or use (Csótó, 2010).

2.4 Sugarcane Smoke Mitigation Programs

The sugarcane production cycle often requires prescribed burning in the harvesting process. The sugarcane plant is 75-80% cane stalks, which is the desired product, and 20-25% extraneous leafy material (LSU AgCenter, 2000). The leafy remnants that are not wanted are usually burned before or after the cane is harvested. Without being burned, the leftover trash can both decrease the following year's crop yield and put economic burdens on the industry. If the layer of leafy material remains on the field, it will dry out the soil as well as release allelochemicals while it decays that will prevent the germination of the sugarcane seed the following season (LSU AgCenter, 2011). Alternatively, moving the leafy material from the field would cost the industry an estimated $24 million for transportation and processing annually (LSU AgCenter, 2000). Burning sugarcane fields reduces the energy expenditure of the farmers, eliminates unnecessary wear of field and factory machinery, decreases the amount of material that factories process, and shortens the harvest season by 10% (LSU AgCenter, 2000). Until an equally economically efficient way to eliminate the excess is discovered, sugarcane burning will remain a necessary harvesting method, meaning that smoke and ash management, or the act of conducting a prescribed burn during recommended atmospheric conditions, will be used to mitigate the effects on the nearby community ("Louisiana smoke management," 2011).

An overview of the smoke mitigation efforts in the sugarcane producing states highlights the opportunity for an online application as well as provides a general understanding of the common themes found in all smoke mitigation programs. In addition to the study area of Louisiana used in this research, sugarcane is grown commercially in Hawaii, Florida, and Texas (Meagher, n.d.), each of which have their own state instituted policies designed to be in compliance with the USDA Agricultural Air Quality Task Force (AAQTF) – a group mandated by Congress to address air quality issues in agriculture (USDA Agricultural Air Quality Task Force, n.d.). A summary of each state's policies is summarized next to demonstrate the similarities and differences between programs.

Hawaii. The competing uses for sugarcane farm land have reduced the amount of sugar production on the island state. In the 2000s, Hawaii harvested an average of 20,700 acres annually compared to the near 100,000 acres of sugarcane that were harvested in 1981. Expectedly, the sugar production of the state declined from 1 million tons annual average in the 1980s to 238,000 tons in the 2000s (USDA Economic Research Service, 2012). The state of Hawaii Department of Health (DOH) runs a mandatory smoke mitigation program. Open burning is prohibited without a permit; the permit application requires a burn schedule, field map, scale of burn, and meteorological information. A burn permit fee is paid based on the acreage planning to be burned and the program is enforced by DOH through a field citations program. Farmers are restricted from burning on "No Burn" periods deduced by the DOH Clean Air Branch, if they are along major highways, may impact the airport, or are immediately adjacent to residences or other public areas (with the exception of specific wind conditions and limited burn times). Also, all farmers are recommended to send out public notifications before conducting a burn through flyers, written notices, sugarcane burn "call lists", road signs, etc. Standard conditions are specified in the burn permit for small-scale burns, such as appropriate meteorological conditions, while more extensive requirements exist for larger burns.

When a burn passes a size threshold, they are required to complete written burn procedures that include a meteorological data assessment, public notifications summary, a completed Burn Monitor Log conducted during the burn, and all efforts done to minimize smoke emissions from smoldering piles post-burn (“Regulation of agricultural burning,” n.d.).

Texas. Sugarcane is grown in the subtropical climate of the lower Rio Grande in Texas. It is the 3rd largest sugarcane producing state in the U.S., behind Florida and Louisiana, with an average of 42,000 acres harvested in the 2000s (USDA Economic Research Service, 2012). According to the Outdoor Burning Rule, Title 30, Texas Administrative Code, outdoor burning is prohibited anywhere in Texas, with outlined exceptions for situations where it does not cause a threat to the environment or is necessary. If the reason for burning is not called out as an exception to the rule, one can request special authorization from the Texas Commission on Environmental Quality (TECQ). Burn permits are not a part of the program, but all burning must comply with the conditions set in the exceptions to the Outdoor Burning Rule (“Outdoor burning in,” 2008).

Sugarcane growers are an exception to the rule because the state determined that burning is a necessary practice of the industry. The conditions set on sugarcane farmers include an oral or written notification to the TCEQ (which includes a map of the area being burned, the approximate start and end time, and the party responsible for the burn), checking of local ordinances for “No Burn” notifications or other restrictions based on local meteorological conditions, and to stay outside of a 300 foot buffer from any potentially sensitive areas unless written permission from the occupants is obtained. A sensitive area is defined in the document as a residence, business, any other public structure, and major roadways that are adjacent to or downwind from the burn ("Outdoor burning in," 2008).

Florida. With 433,000 acres harvested, Florida is the largest sugarcane producer in the U.S., most of its growth taking place since 1960 when the U.S. stopped importing sugar from Cuba (Meagher, n.d.). The Florida Forest Service provides a number of Fire Weather Tools, which is discussed in a section to follow. It is interesting to note that basic prescribed fire training and certification for experienced burners is available through Hillsborough Community College's Certified Burner Program, but farmers are charged tuition fees ranging from $175 - $275 per student (Florida Forest Service, n.d.).

The following five-step Smoke Screening Process is a required procedure for all sugarcane burns:

1. *Plot probable smoke impact area* (30 degree arc on either side of the wind direction tangent)
2. *Identify smoke sensitive sites* (if none, may burn as planned, if 1 or more, continue screening process)
3. *Identify critical smoke sensitive areas* (a chart is provided indicating the nearer distances from the burn that are considered a critical, and more heavily affected, area. If any sensitive sites are located within this area, burning is prohibited).
4. *Determine fuel type and loading*
5. *Complete the 'Minimize Risk Checklist'* (specifics appropriate meteorological conditions)

The program and meteorological information is managed by the Florida Forest Service (FFS). The program does not specify an enforcement procedure, but it is said to be mandatory. The FFS website provides a general sentiment of the program through this communication to its constituents:

> If we are willing to use relatively simple guidelines that have already been developed, and continue to search for better ones, we can demonstrate to regulatory agencies and the public that we act responsibly and will avoid adverse impacts of public safety and welfare (Florida Forest Service, 2004).

Louisiana. Louisiana is the northernmost cane-growing State and is the 2nd largest producer next to Florida, harvesting approximately 358,000 acres each year ("Prescribed burning background," 1992; Meagher, n.d.). The Louisiana Department of Agriculture and Forestry, the American Sugar Cane League, and the LSU AgCenter published the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* to guide a voluntary smoke and ash management program ("Louisiana smoke management," 2011). The purpose of this program is to provide sugarcane producers with techniques and training to mitigate the smoke plume effects on sensitive sites and confer the Prescribed Burn Manager title that is technically needed to conduct burns in the state. Following the guidelines is highly encouraged but remains a voluntary practice and none of the organizations involved practice enforcement. The recommended procedures are as follows:

1. *Identify Areas Sensitive to Smoke and Ash*
   The guidelines suggest obtaining a map of the field to be burned that displays sensitive sites within a 20-mile radius. Sensitive sites include airports, highways, recreation areas, schools, daycares, hospitals, nursing homes, power lines, substations, and gas lines.

2. *Obtain Fire Weather Forecast*
   The fire weather forecast provides surface wind variables, transport wind variables, and the category day. A list of websites that contain this information is provided in the guideline document.

3. *Develop a Prescribed Burn Plan*
   The guidelines provide a specific Prescribed Burn Plan form that asks for the following information before burning takes place: surface wind speed and direction, transport wind speed and direction, surface inversion lifting temperature, and acceptable ranges in weather. The acceptable range is determined by individual growers by consulting the map showing sensitive site locations.

4. *Determine Smoke Category Day*
   The smoke category day mandates if burning is allowed to occur and at what time in the day would accommodate optimal smoke dispersal. The guidelines say that this information can be found in the fire weather forecast from each sugar mill or the Internet.

5. *Determine Smoke and Ash Screening Distance*
   A table is provided indicating the potential impact area in miles given the type of burn and the smoke category day.

6. *Determine Trajectory of Smoke and Ash Plume*
   The farmer is instructed to draw a smoke trajectory directly on a map that stems from the burn site in the wind direction at a length of the smoke and ash screening distance determined in step 5. Next, two additional lines from the burn site are drawn at a 30 degree angle from the center line. The containing area is the projected smoke and ash plume shape and size.

7. *Evaluate the Prescribed Burn Results*
   After the burn is complete, the farmer should record the results and degree of success of the burn on the burn plan and keep the completed document for future reference.

Compare and Contrast. Because each state office designs the details of sugarcane burn policies, variations exist state-to-state, but some common threads are seen throughout. The first, and possibly the most important, commonality shared by all of the policies is that they allow for sugarcane burning, albeit with a set of conditions. Even though research has proved that the particles and gases produced from sugarcane burns pollute nearby communities and have adverse health effects, it is still an allowed practice (Arbex et al., 2007; Cançado et al., 2006; "Prescribed burning background," 1992; Mazzoli-Rocha et al., 2008). Just as all states recognize that sugarcane burning is a necessary harvesting technique, they also understand the need for restrictions to mitigate smoke effects. They all have authorities that can issue "No Burn" days and all require marking the location of sensitive sites and consulting meteorological information such as wind speed, direction, and atmospheric stability prior to each burn. All programs also require documentation of the burn, either in the form of a permit application or burn plan, and each plan involved indicating the field location on a physical map. From the perspective of a GIS developer, there is a clear opportunity to use a digital map already displaying residences and other sensitive sites on which to apply a model-based predicted smoke plume. Even though each state's program would require a slightly different model based on the details of their own rules, their similarities of requiring burn documentation that involves drawing on a physical map and modeling smoke based on meteorological conditions make them all possible users of the Sugarcane Burn Planner or another similar application.

Besides the nuances associated with defining burn restrictions based on distance from a sensitive site, wind speed, time of day, etc., the most notable difference between state smoke mitigation programs is the degree of formality (Table 2.1). Burn permits are one dimension of program formality, with permits required in Hawaii, notifications to the TCEQ required in Texas, and no permits required in Louisiana and Florida. Fees differ from state to state as well – with training fees in Florida, permit fees in Hawaii, and no fees in Texas or Louisiana. And finally, enforcement is only explicitly discussed by Hawaii's protocol while the mandatory programs in Texas and Florida only imply the possibility of rule enforcement. Louisiana is the only mitigation program that is voluntary, elevating the need for proper documentation and easy-to-use tools that encourage participation, making it a very appropriate study area to introduce and assess the community's perception of a new smoke mitigation application.

Table 2.1 Comparison of State Smoke Mitigation Programs

	Hawaii	**Florida**	**Texas**	**Louisiana**
In compliance with federal law set by USDA AAQTF	Y	Y	Y	Y
Allows for sugarcane burning	Y	Y	Y	Y
Requires burn documentation	Y (permit application)	Y	Y	Y
- Plot on physical map	Y	Y	Y	Y
- Stipulations based on meteorological conditions	Y	Y	Y	Y
Requires permit	Y	N	N (but notify TCEQ)	N
Fees	Y (permit fees)	Y (training fees)	N	N
Mandatory mitigation program	Y	Y	Y	N
Enforcement of mitigation program	Y	Y (implied)	Y (implied)	N

2.5 Existing Similar Technologies

Many fire and smoke geospatial tools and applications exist, but none were built with farmers conducting sugarcane burns in mind and cannot adequately serve this sect of the sugarcane industry. Understanding the limitations of existing technologies used for similar purposes supports the argument for a new application to be developed and analyzing the advantages and shortcomings of each aid in the development process. The two most inclusive lists of emissions/smoke management/air quality monitoring tools and applications are distributed by major players in fire management policy and research, the U.S. Forest Service and the National Wildlife Coordinating Group (U.S. Forest Service; "Wildland fire applications," 2003). These lists, in combination with any provided directly from state smoke mitigation programs, are used as the basis for what is analyzed here; a complete list of which is found in Table A.1. The modeling algorithms vary among the tools, but are not the focus of this research, which maintains emphasis on the probability of use based on the user experience. The limitations of these tools and applications are grouped into three main categories: the inputs, outputs, and technological limitations.

Input Limitations. When viewing these applications from the perspective of a potential sugarcane farmer user, the sheer number of inputs required to run many of the tools are an obvious limitation. Examples of the overwhelming nature of input screens include the Fire Emission Production Simulator or FEPS (Figure A.1), the Simple Approach Smoke Estimation Model or SASEM, and the Smoke Impact Spreadsheet or SIS. The input requirements may be appropriate for a different user target audience but is obviously not designed for the sugarcane farmer community for the purpose of smoke plume mitigation because it is not practical for day-to-day use. In other applications, the inputs needed are not easily attainable. The Spot Weather Forecast tool (Figure A.2) provided by the Florida Forest Service requires on site weather observations of temperature, humidity, wind speed and wind direction, meaning that each farmer would need to own these measurement tools and collect this data themselves. CALPUFF is another example, requiring geophysical and meteorological data files to upload into the model. Even if an individual can meet some of these stringent input requirements, the end product often does not provide information useful to their purpose.

Output Limitations. The outputs, or information generated from the application models, vary in format and content. The formats range from purely tabular, to graphical or statistical, to geographic or map-based. A tabular output has its uses, but is not the most effective method of communicating inherently geographic information. Many of the examined applications produce output in this format, including the First Order Fire Effects Model or FOFEM (Figure A.3), SIS, SASEM, FEPS, and the Spot Weather Forecast. The Ventilation Climate Information System or VCIS (Figure A.4) was the lone application analyzed providing a graphical output, like the wind rose to show wind speed and wind direction or mixing heights in a vertical bar graph. This approach may be more suitable for research purposes, but is still not ideal for the sugarcane farmer use case.

The geographic nature of predicting where the smoke will travel and what nearby areas it may negatively impact implores a geographic solution. Some applications and tools do have mapping components, like the maps provided by the Florida Forest Service (Figure A.5), the California and Nevada Smoke and Air Committee or CANSAC, and the Interagency Real Time Smoke Monitoring application developed by the California

Environment Agency Air Resources Board. The most apparent drawback to each of these is that they are fixed to the state they are supporting and cannot be applied in the study area of Louisiana. In addition to its border limitations, these static maps also restrict the scale in which the model can be applied. Since many of these tools were designed for prescribed forest or wildland fires, the scale is smaller than what is suitable for an agricultural prescribed burn, as seen in the fixed scale of the Rapid Access Information System or RAINS (Figure A.6). Regardless of input requirements and output format and information, users cannot use a tool or application that requires technical knowledge beyond their capabilities.

Technological Limitations. There are three areas of technical requirements found in this group of fire/smoke tools and applications that limit potential users: software, download, and high technical knowledge prerequisites. Some software requirements are larger than others; the California Emission Estimation System is only run in ArcMap, which is a license farmers do not commonly own. The Interagency Real Time Smoke Monitoring needs a Java plugin, which is easier to acquire, but may still rule out possible users. Many of the tools and applications are downloaded and installed on the user's machine (SASEM, SIS, CALPUFF, FOFEM, and BlueSky). Downloading and installing large files is not ideal because of the start-up time and use of computer resources. Many of these tools and applications have a moderate to large learning curve associated with their use. Those that are downloaded and installed have a wide variety of user interfaces and training on these programs often only exists in the form of a user's manual that is too long and cumbersome to be considered practical for the purposes of sugarcane farmers. Between the input, output, and technological limitations found in existing tools and applications, a clear opportunity is presented for an online application designed specifically for farmers to mitigate sugarcane smoke.

2.6 Effectiveness of Agriculture R&D Outreach/Extension Efforts

McCown, Brennan, and Parton (2006) discuss the divide that exists between academic research and applicability in farm management. Their research, looking specifically at production economics, has found that farm management research is out of touch with farmers' real needs and has lost sight of the practicality of farming, with most of the research being very logical but not applicable to day-to-day practices. His conclusions suggest that research and the development of technology in agriculture should not focus as heavily on the complexity of the farms (they are extremely complex and often the technology only addresses a small portion of the complex system, making it unattractive to use), but instead on explaining *uncertainty* associated with farm management. If something can make expectations more useful in an area of uncertainty, it is more applicable and thus has higher adoption potential. "Publicly funded agricultural" (2002) also argues in favor of agriculture extension program evaluations because they has such diverse constituents, especially considering the number of small and medium-sized farms, and the design of their programs should reflect this challenge.

A larger research project about how different meteorological conditions affect sugarcane burns purposed the development of the online application tested in this thesis. But just because an application is built for this community of farmers does not mean that they will adopt and regularly use it, and this thesis research helps to answer the question of if this is an effective extension effort. Because, as Öhlmér (2007) states, researchers normally know what the farmers should do but not so much about what the farmers actually do. The large political debate about the appropriate level of public funding, quasi-public funding, and private funding for research outreach and extension is on-going. By studying the costs and benefits of these efforts, the actual (vs. the supposed) demand for information technology can be quantified, making us better equipped to efficiently use allocated funding (Michailidis, 2006).

2.7 Summary

Because there are no publicly available tools or applications that specifically address the challenges of the sugarcane farming population in content or design, I hypothesize the results of this study will show high overall adoptability measures of the Sugarcane Burn Planner. If this hypothesis is correct, the opportunity opens up for the application to be utilized in other state mitigation programs based on the analysis showing their similar paper-based mapping and modeling components. High adoptability ratings would also support the development direction of creating simpler decision support programs that reduce uncertainty for agriculture R&D extension and outreach initiatives.

Based on previous studies in technology adoption in agriculture, I hypothesize that age (Q7) and farming experience (Q12, Q13) are negatively correlated to adoptability of the Sugarcane Burn Planner and education (Q7) and farm size (Q14, Q15) are positively correlated. High rankings for internet importance (Q18), device ownership (Q19), and using a computer in the field (Q20) will likely be correlated to higher adoptability ratings since the application is hosted online and can be accessed by multiple devices. Because the application has an interactive mapping component and automatically populates weather variables, I hypothesize that the use of the Internet for mapping applications (Q17) and weather forecasts (Q17) will also be positively correlated with adoptability because the map will feel more familiar and weather data is presented in a more consumable format. In regards to the community focused variables, those who perceive themselves as nearer sensitive sites (Q21) and more people (Q22) probably place more importance on smoke mitigation and are more likely to adopt the Sugarcane Burn Planner if they find it easy to use. Conversations with LSU AgCenter personnel lead me to believe that the current mitigation program has high participation, so I hypothesize that the questions measuring involvement (Q23, Q24, Q25, Q26, Q27) will reflect this and be positively correlated with adoptability, as the Sugarcane Burn Planner is a replication of the process they are already using at an assumed high rate.

CHAPTER 3

RESEARCH DESIGN AND METHODS

3.1 Application Design

The first portion of this research consists of identifying the appropriate combination of application design, development platform, and access portal for the Sugarcane Burn Planner to appropriately serve managers in the sugarcane industry. The development goal was to recreate the existing *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* publication in a digital format and make it publicly accessible online with the hope that it will save time and effort when completing a burn plan as compared to the manual paper process. The application design process followed the beginning stages of the Systems Development Life Cycle (SDLC) – the Current State Analysis, Requirements Definition, and Application Design. The deliverables in Table 3.1 were completed as part of these steps.

Table 3.1 SDLC Documents

Current State Analysis	Systems Overview* As-Is Use Case As-Is Process Flow* Known Issues List*
Requirements Definition	To-Be Use Case To-Be Process Flow* Risk Assessment*
Application Design	Screen Prototypes Interface Description*

(* indicates the document can be found in the Appendix B)

The application was written in C# using Microsoft Visual Web Developer 2010 Express and in Javascript with the Google Maps API. Other platforms, such as Flashbuilder and the ArcGIS API for Flex or HTML5 and ArcGIS for Server, were considered in the process. The combination of Visual Web Developer and the Google Maps API was chosen because it provides the user with the most familiar default interface, with the usual banner at the top and a commonly used border seen in many other websites. The use of ArcGIS for Server was not appropriate for this project due to licensing restrictions. The geographic model implemented in the Sugarcane Burn Planner (Version 1.0 used for this thesis) is very simple but the Google Maps API allows for increased model dimensionality to be added in subsequent versions. The development stage used a more adaptive than predictive method, following an informal agile-based approach. Multiple iterations of development produced interpretations with varying functionality, with each rendition receiving feedback followed by subsequent adjustments.

The To-Be Process Flow (Appendix B) charts the flow and interaction between the user and the application. It is designed as a singular web page that follows a very linear, 5-step process: (1) Zoom to the Area, (2) Add Marker to the Field (3) Set Date/Time (4) Define Burn Parameters (5) Save/Print Burn Plan. These steps fulfill the requirements set by the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* in the following ways:

1. *Identify Areas Sensitive to Smoke and Ash* – The Google Maps API allows the user to toggle the map between street layout and the default satellite view. The satellite view allows the user to see where the sensitive areas (such as airports, highways, schools, etc.) are located.

2. *Obtain Fire Weather Forecast* – Wind speed, wind direction, and temperature are automatically populated in the application based on the location, burn time and burn date indicated in application steps 1-3. Some of the other weather variables require a lookup and input from the National Weather Service (NWS) site.

3. *Develop a Prescribed Burn Plan* – The same values that are recorded in the paper burn plan are required in the Sugarcane Burn Planner and the final burn plan may be printed and/or saved when completed.

4. *Determine Smoke Category Day* – This variable can be found from the NWS site, which is linked to from the application.

5. *Determine Smoke and Ash Screening Distance* – The smoke plume model in the Sugarcane Burn Planner automatically calculates the plume distance based on the entered weather variables.

6. *Determine Trajectory of Smoke and Ash Plume* – The smoke plume model also automatically determines the trajectory or direction of the plume based on the weather variables.

7. *Evaluate the Prescribed Burn Results* – The completed burn plan can be saved and/or printed for accurate record-keeping and evaluation.

The interface of the Sugarcane Burn Planner (v 1.0) incorporating these steps is seen in Figure 3.1.

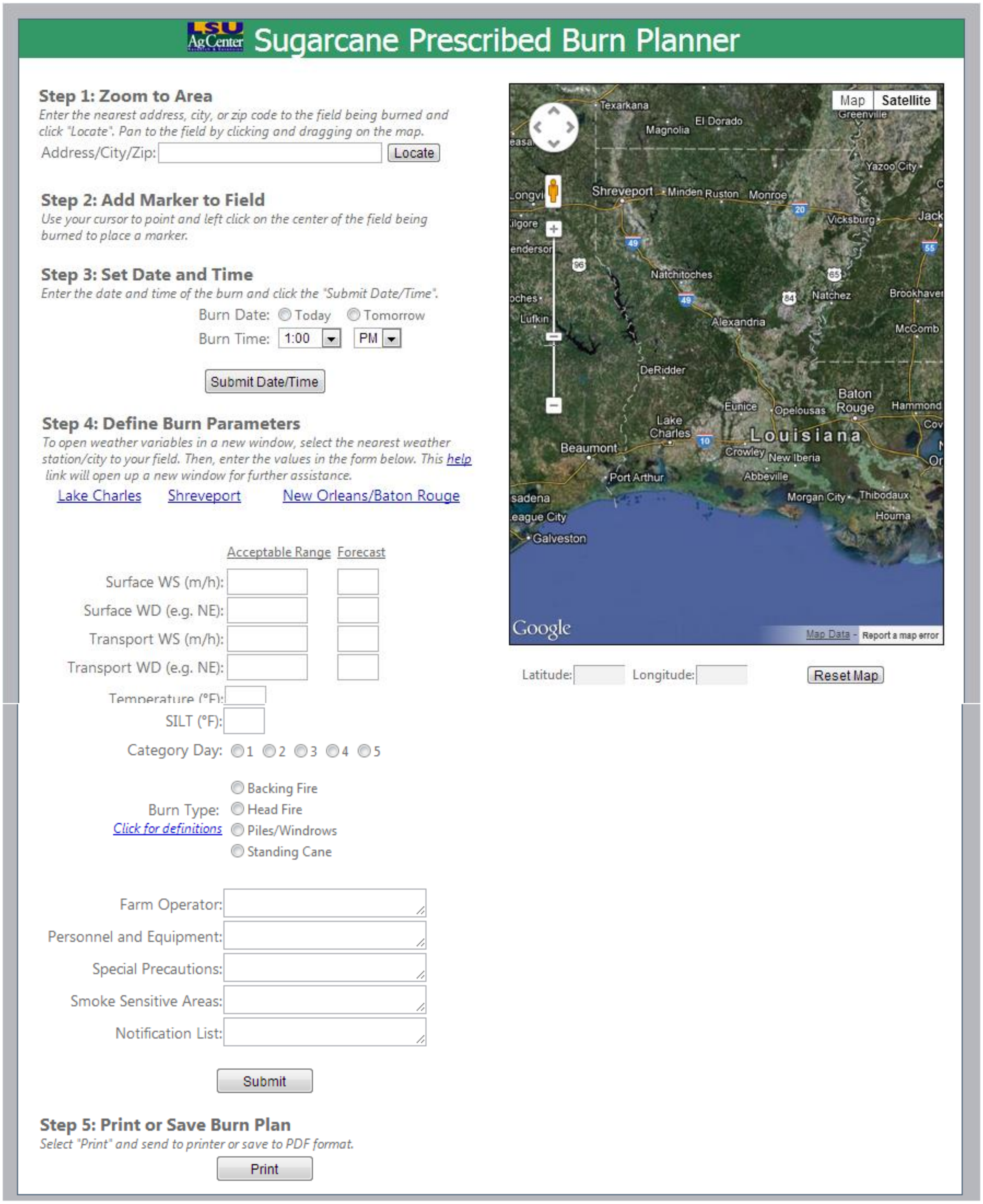

Figure 3.1 Sugarcane Burn Planner Interface

3.2 Survey Design

After the completion of the Sugarcane Burn Planner, a 4-minute video was recorded demonstrating its capabilities through an example burn plan. The survey that follows the video contains questions on Application Usability, Demographics, Technology Resources and Use, and Community. The best practices discussed in Dillman, Smyth & Christian (2009) provided structural guidance to the survey questions (seen in Appendix C) and previously conducted similar studies in combination with the research questions of this thesis directed the question content. Each section of survey questions is defended next with an explanation of how these questions relate to the research questions.

Application Adoption. The first set of survey questions is focused on collecting feedback after viewing the video clip demonstrating the application. These questions are used to measure the survey participant's perception and adoptability of the application and will aid in achieving the research goal of assessing if a relationship exists between the adoptability of the application and other demographic, technology, and community variables. The more practically based research questions answered by the survey are "Will sugarcane farmers use this application?" and "Is it practical to integrate the application into the existing Louisiana sugarcane smoke mitigation program?" Questions in this section ask about how they would use the application, how they would rate its usability, what they believe are the most useful features, and, with all else considered, how likely they are to use it in the future.

Demographics. The demographic survey questions elicit age, education level, farming experience (measured by years in their decision-making role and years in the sugarcane industry), and farm size (measured by burns per year and acres of sugarcane). The relationships between these variables and computer and Internet adoption are well established in the literature and are included in this study to see if these relationships persist. Based on the findings of previous studies, it is hypothesized that age and farming experience are negatively related to adoption and education and farm size are positively related. For example, older and experienced farmers are less likely to adopt while more educated farmers are more likely to adopt. Farm address is an additional demographic question asked that is not found in other studies. The purpose of this question is to understand the farm's proximity to the community, which is a unique additional layer of influence because of the inherent geographic nature of the sugarcane burn smoke problem. It would be reasonable to hypothesize farms nearer to more public structures (e.g. schools or churches) and heavily populated areas would be more likely to adopt the application.

Technology Resources and Use. The possession and use of a computer and/or the Internet is often thought of as a dependent variable determined by other factors, but it as an independent variable in many technology adoption studies. Questions in this section ask about Internet access, the frequency of use of other Internet applications, what devices (laptop, desktop, smartphone, etc.) he/she has access to, and if a computer is used in the field. It is reasonable to assume that the likelihood of adoption of the Sugarcane Burn Planner is higher for those who own more Internet-accessible devices and already frequently use other online applications. An additional question asks what *importance* the Internet has for his/her farm practices. All of these variables are critical to assess the existing role and perception of personal technology use in this sector of agriculture.

Community. The farmers' behaviors and attitudes towards the surrounding community are hypothesized to influence the adoption of the Sugarcane Burn Planner because the application's ultimate goal is to protect the community from breathing in unhealthy smoke particles and assure visibility on transportation routes. The questions that collect information on their behavior in regards to the community include how many smoke mitigation training sessions they have attended, how long ago they attended a training session, and how often they produce a completed burn plan. The farmers' attitudes towards or perception of the community are assessed through questions about how effective and important they believe the smoke mitigation program to be as well as how many people they think are located within a 5-mile buffer of their burns that may be affected. Their population estimation is compared to the actual number determined by a GIS buffer analysis of the field address. This study includes a geographic perspective and differentiates the research from many past agriculture technology adoptability studies.

3.3 Sample Selection and Survey Distribution

The limitations of this study stem from the survey sample size and nature of the sample. The original research intent was to sample all of the community of sugarcane farmers in Louisiana, but, since the survey was distributed via contact information collected by the LSU AgCenter, the population sampled is actually personnel in the Louisiana sugarcane farming business that have an association with the current smoke mitigation program. The actual sampled population of 344 (i.e. existing smoke mitigation program participants) does not allow for analysis to see if the application has the potential to encourage brand new involvement in the program. The sample can still relate level of participation in the program to adoptability of the application, which is measured by the 'Community' survey questions. In 2012, there were 475 sugarcane farms in Louisiana covering over 400,000 acres (American Sugar Cane League, 2013). If each email address represents a farm manager of a unique farm, the population sampled represents 72.42%

of the actual population. This is an estimated number, as farms may have had multiple employees participate in the mitigation program.

To distribute the survey, an e-mail was sent to a listserv managed by the LSU AgCenter of approximately 344 email addresses of sugarcane farmers, consultants, and researchers in Louisiana (the sampled population) containing links to a 4-minute video demonstrating the application and the online survey. By watching the video and completing the 27 survey questions survey, participants were entered into a raffle as incentive to participate. Because the video and survey were administered online through e-mail, the sample may be somewhat biased as it is composed of population members that probably check their e-mail more often and are more comfortable with the Internet considering they are willing to view a video online and take an online survey. The survey responses summarized in Table 3.2 show that the respondents are more technologically savvy than the average farmer in the South, according to USDA National Agricultural Statistics Service (NASS) statistics (discussed further in Ch. 4.3). The survey remained open for 3 weeks. The total number of received responses was lower than expected, most likely due to a large-scale survey administered to the same listserv at the same time by LSU AgCenter researchers. The effect of the small sample size (20) is most obviously seen in the restricted type of statistical methodology that could acceptably be applied.

3.4 Statistical Methodology

A total of twenty survey responses were collected; seventeen were 100% complete. The analyses of this study only included completed responses, so some survey questions were analyzed with an n of twenty while others have an n of seventeen. By standard measures, this is considered a small sample size ($n<30$) and analysis is restricted to nonparametric methods, descriptive statistics, cross-tabulation analysis, graphical pattern analysis, and theorization. Table 3.2 shows the variable associated with each survey question and the measure of central tendency of the respondents. The Kruskal-Wallis and Spearman's rho tests were used to identify statistically significant correlations between the likelihood of adoption and usability measures (Q2, Q3, Q4) and each individual demographic, technology, and community variable. The likelihood of adoption and usability questions were answered on a Likert scale. When these responses were compared to nominal responses, the Kruskal-Wallis test was used, and the Spearman's rho was used when comparing interval level data to other interval level data. Scalar responses, such as farm acreage or number of burns per year, were grouped into nominal level data (such as small, medium, and large farms) and compared to usability measures via the Kruskal-Wallis test.

When the likelihood and usability measures are removed from the analysis, the demographic characteristics remain an independent variable and the technology and community variables become dependent. To compare the three categories of characteristics, two indices were developed to represent technological use and knowledge and involvement in the mitigation program and then compared graphically against farmer demographic characteristics of age, education, farming experience, and farm size. A visual analysis of graphs showing the overlay of these variables was used to answer the related research question.

Table 3.2 Survey Results Summary

Variable Name	Survey Question	Measure of Central Tendency [a] = mean “ ” = categorical [b] = mode [c] = ordinal [d] = scale	Value Range
Adoption			
Adoptability			
- Type of Use	Q1	“Instead of paper burn plan” [b]	N/A
- Likelihood of Use	Q4	4.20 [ac]	3-5
Usability	Q2		
- Will Save Time		4.31 [ac]	2-5
- Is Easy to Use		4.35 [ac]	4-5
- Is Intuitively Designed		4.25 [ac]	4-5
Feature Usefulness	Q3		
- Auto Weather Variables		4.40 [ac]	3-5
- Drawn Smoke Plume		4.70 [ac]	4-5
- Printable		4.61 [ac]	4-5
Demographic			
Age	Q7	49.89 [ad]	36-66
Education	Q8	“Graduate Degree” [b]	N/A
Farming Experience			
- Years in Role	Q12	“More than 20 years” [b]	N/A
- Years in Industry	Q13	“More than 20 years” [b]	N/A
Farm Size			
- Burns per Year	Q14	27 [ad]	4-50
- Acres	Q15	1583.94 [ad]	290-5000
Technology			
Internet Access	Q16	19=Y; 0=N	19=Y; 0=N
Internet Use	Q17		
- Entertainment/Social Network		3.11 [ac]	1-4
- Weather Forecasts		3.79 [ac]	3-4
- Online Banking		3.26 [ac]	1-4
- Info from Research Institutes		3.42 [ac]	2-4
- Look up Input Prices		3.21 [ac]	2-4
- Info on Farm Best Practices		3.63 [ac]	3-4
- Recruitment		1.84 [ac]	1-4
- Info on New Farm Technologies		3.25 [ac]	2-4
- Mapping Applications		3.37 [ac]	2-4
- Look up Yield Prices		3.21 [ac]	1-4
Internet Importance	Q18	4.39 [ac]	2-5
Device Ownership	Q19	2.84 [ad]	1-4
Use Computer in Field	Q20	16=Y; 2=N	16=Y; 2=N
Community			
Perceived Distance from Sensitive Sites			
- In miles	Q21	“Very close (<1 mile)” [b]	N/A
- In # of People Affected	Q22	2167.92 [ad]	40-10,000
Training Sessions			
- # Attended	Q23	3.07 [ad]	1-4
- Time since Last Attended	Q24	“1 to 5 years ago” [b]	N/A
Burn Plan Completion	Q25		
- Step 1		3.15 [ac]	1-4
- Step 2		3.38 [ac]	1-4
- Step 3		2.77 [ac]	1-4
- Step 4		3.46 [ac]	1-4
- Step 5		2.85 [ac]	1-4
- Step 6		3.38 [ac]	1-4
- Step 7		3.00 [ac]	1-4
Program Evaluation			
- Effectiveness	Q26	4.00 [ac]	1-5
- Importance	Q27	4.69 [ac]	3-5

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Correlations to Adoption, Usability, and Usefulness

Survey question #4, "If made available, how likely are you to use this Internet-based Burn Planner application in the future?", measured the likelihood of adoption. Perceived usability was measured by survey question #2, asking if they believe the Sugarcane Burn Planner will save time, looks easy to use, and is intuitively designed. Survey question #3 measured perceived usefulness, asking if they find the following features useful: the automatic weather variables, the smoke plume drawn on the map, and the printable burn plan. All of the responses to these questions were compared to the demographic, community, and technology survey answers and the variables that were found to be significantly correlated (seen in Tables D.1 to D.6) are discussed further.

Likelihood of Adoption. Not surprisingly, the likelihood of adoption is positively correlated to related questions regarding perceived usability and usefulness of application features, excluding the printable burn plan feature, explained further by these open response answers:

> "One aspect that can be improved upon is modifying step 5, the printable burn plan. I think it would be more useful to save the burn plan in a database and have an option that allows for printing records later."
>
> "It would be hard to print in the field."

The application does have the ability to save the burn plan, but it is done so through the printing interface, which is confusing and not familiar to users. The reaction to the printing feature speaks to the user preference of *when* and *where* they would likely use the application, suggesting that it is unlikely that they will sit in front of a desktop computer connected to a printer before every burn starts.

Looking at the relationship between perceived usability and usefulness measures and overall likelihood of use peels back the layers revealing what application characteristics drive its adoption potential. All other factors aside, it is obvious that an application that is easy to use and well-designed is more likely to be used. But it is also worthwhile to know that saving time was the usability measure with the strongest correlation with likelihood of r=.703 at the p<.001 level. Measures of feature usefulness are equally as important because a very usable application may still not be adopted if it does not have the features expected by the user. The highest correlated useful feature with likelihood of adoption was the drawn smoke plume (r=.654 at the p<.005 level).

Likelihood of adoption was also significantly correlated with the use of Internet applications to look up information from research institutes, look up of farming best practices, look up of new farming technologies, use of other mapping applications, and the look up of yield prices. These correlations paint a good picture of the Internet experience of the person likely to use the Sugarcane Burn Planner. They are people who use other Internet applications often and are motivated to find the ‘latest and greatest’ tools and advice to make their farm practice as effective and efficient as possible. It also shows that familiarity with other mapping applications, such as Google Earth or Bing

Maps, provides a comfort level with the Sugarcane Burn Planner that uses a similar interactive mapping component.

Lastly, the number of training sessions on the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* attended is significantly, positively correlated with the likelihood of adoption, suggesting that those who are more acquainted with the steps in the manual process would be more comfortable with those same steps in digital form. The overall results of significant correlations with likelihood of adoption indicates that the LSU AgCenter, which is a commonly referenced research institute and the managers of the current manual mitigation process, is a pivotal resource in smoke mitigation in Louisiana and an appropriate launching point for the Sugarcane Burn Planner application.

Usability. When asked if they believe the Sugarcane Burn Planner application will save time, the response “Undecided” was given 7/20 times, the most for any question in this survey section (Figure 4.1). There are a few possible reasons why respondents felt they could not decide how to answer this question. The video demonstrated the use of the application and they may have been more equipped to answer this question if able to use it themselves directly. Also, some may believe that a learning curve and/or an adjustment period that takes more time is unavoidable, but that it will eventually save time once it is familiar and easier. One respondent who answered “Undecided” calls out the look up of weather variables as not very efficient in the free response section implying that its complexity is time-consuming, saying:

> “If possible it would be good to have only the needed information when the National Weather Service page is looked up. I think many producers are somewhat confused by all the "other information" that is shown.”

Finally, they may see the act of sitting at a computer to access the application before the burn takes place as something that requires greater time and effort than marking on a paper in the field at the time of the burn. Some of the free response answers (* indicates "Undecided" response) provide insight into the preference of accessing the application while in the field via a mobile device:

> "Everything looks great to me and we have several iPads in our operation to facilitate the process."
>
> "This will also be easier to use in a mobile application."
>
> "If used in the field, it would have to be an android or ipad app. I prefer android."*****
>
> "NEED LAP TOP IN FIELD."*****
>
> "It would be hard to print in the field."*****

If the application was better adapted to mobile devices, it would potentially increase the agreement that the Sugarcane Burn Planner would save time in the mitigation process. This is an important change, considering the previous discussion about how 'saving time' was the highest correlated variable to likelihood of adoption of the application. Answers to survey question #19 and #20 show that the technology that these farmers own supports this idea, with the majority of respondents owning three or more Internet-accessible devices and most farmers indicating they use some type of computer (laptop, smartphone, or tablet) in the field.

Similar to the likelihood of adoption variable, the use of internet applications to look up farm best practices and new farm technology are significantly and positively correlated with agreeing that the application will save time. A person who seeks out the newest technology and best practices would not see using a new application as much of an added effort or time expense because of their experiences with other new technologies. There was also a positive significant correlation with the perceived number of people within a 5-mile radius affected by their sugarcane burns, where the more people estimated by the farmer to be affected, the more it is believed that the application will save time (Figure 4.2). This is possibly a result of people taking more time to participate in the currently used manual mitigation process because they believe their burns affect a greater number of people, thus seeing the application as a way to cut back on the time to complete the process.

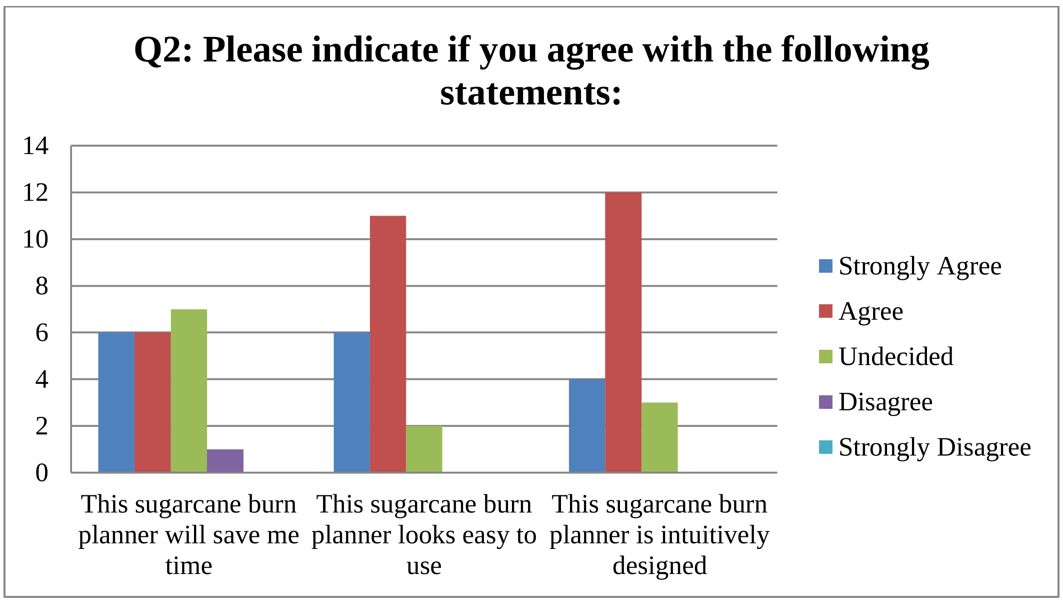

Figure 4.1 Response Total for Usability Questions (Q2)

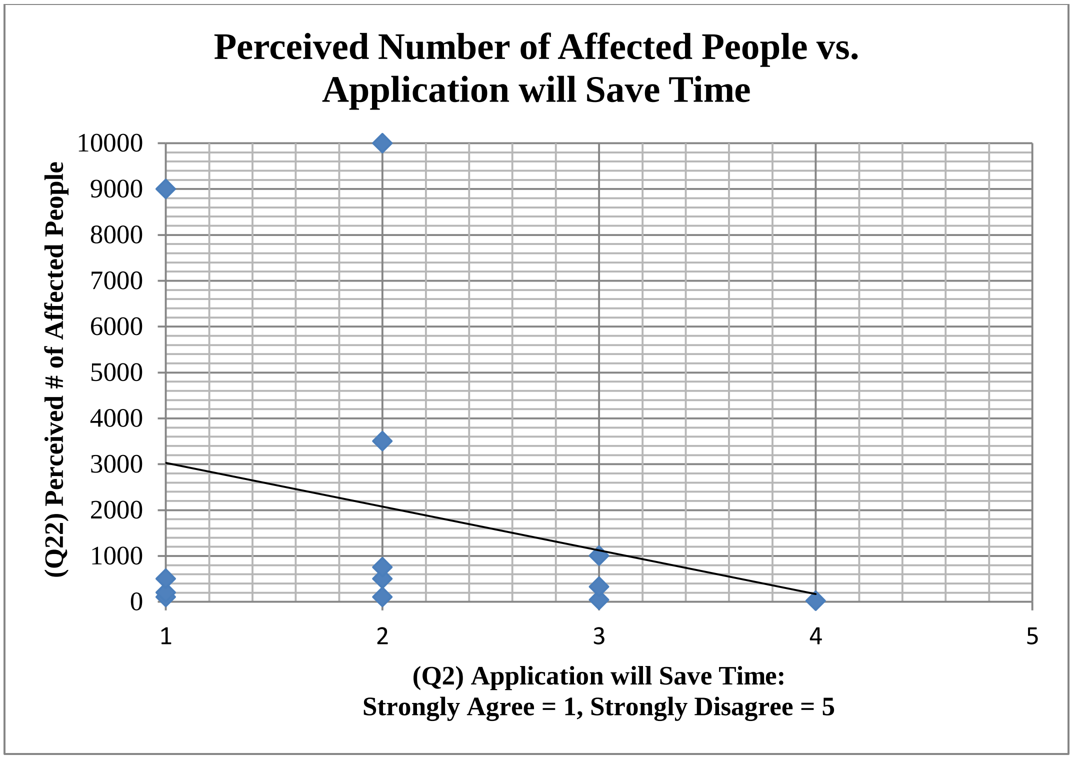

Figure 4.2 Perceived Number of Affected People (Q22) vs.
Application will Save Time (Q2)

The question asking if the application looks easy to use was the only measurement of usability that was significantly correlated to survey question #1 about if they are likely to use the application in combination with or instead of the paper process. The more people find the application easy to use, the more likely they are to consider it an adequate replacement to the currently used paper method. It is interesting to note that the application being 'easy to use' is significant in this way while believing that it will 'save time' or is 'intuitively designed' is *not* correlated to replacing the existing process. In general, this correlation stresses the importance of the ease and straightforwardness of the application.

The ease of use of the application is similarly correlated to the use of Internet applications that were related to likelihood of adoption, such as using the Internet to look up information from research institutes, look up information on farm best practices, research new farm technology, using mapping applications, and searching for yield prices. Additionally, this usability measure is also positively and significantly correlated to the use of the Internet for weather forecasts. If a farmer is already using the Internet for weather information, it is natural that they would find an application that provides weather variables easy to use. In a similar vein, the responses to this question were positively and significantly correlated to how the participants ranked the importance of the Internet to their farming business. The number of devices that can access that Internet provides technological experience that influences a user's perception of the Sugarcane Burn Planner. With a correlation coefficient of $r=.586$ at the $p<.01$ level, the number of Internet-accessible devices is positively and significantly correlated to this usability measurement. Having tablets and mobile devices provide experience with mobile applications, which are often slightly different in design when compared to a typical webpage accessed on a larger laptop or desktop screen.

As expected, finding the application to be intuitively designed is positively and significantly correlated to using the Internet to find information from research institutes, on farming best practices, new farm technology, and yield prices. Like the previously discussed usability measure, it is also correlated to importance of the Internet for farming business and the number of Internet accessing devices owned in an expected positive direction. Measures of Program Effectiveness and Program Importance were also positively and significantly correlated, probably because the design of the application follows almost the exact steps of the currently used mitigation method. If the farmer favors the current method, it makes sense that they would find the application following it as well designed.

Usefulness of Features. There were no significant relationships found between the usefulness of the automatic weather variables and any other demographic, community or technology variable. The usefulness of the modeled smoke plume on the map is positively and significantly correlated to the number of training sessions the respondent has attended. Theoretically speaking, the training sessions may help to emphasize the importance of visualizing this step and demonstrate the time it takes to manually draw it on a map in an accurate way, making this feature seem more useful. Those who found the ability to print the burn plan to be a useful feature were more likely to own a higher number of Internet-accessible devices. If they regularly use more technological devices, they may be more prone to already use a printer and find the printing feature beneficial.

Summary. The general trend of characteristics that are related to the adoption, usability, and usefulness of the introduced online application is that experience with and frequency of use with related technology has the highest influence, with the number of devices, perceived importance on the Internet, and frequency of use of the Internet to access other similar applications being the most commonly found significant relationships. Community characteristics related to participation in the existing mitigation program, such as number of training sessions attended and perceived importance and effectiveness of the program, were also found to be related to the questions concerning the application, but not as frequently as technology characteristics. Demographic characteristics were never found to be significantly related to application use and perception, which was not expected based on their importance in similar, previously conducted studies.

4.2 Demographics

The farmer and farm characteristics studied in this research include farmer age, education, farming experience, and farm size, all of which were variables studied in relation to technology adoption in previous agriculture research. This section discusses how demographic characteristics play into the likelihood of adoption of the Sugarcane Burn Planner and how it compares to the relationships between demographics and adoption concluded in previous studies. Even though no demographic characteristics were statistically correlated to the likelihood of adoption variable, cross-tabulations give insight into patterns or lack of patterns on which to theorize.

Age. Other studies compared age to both technology adoption and the seeking out of information from external sources, with the general consensus being that increased age decreases the likelihood of adoption and decreases the frequency of utilizing the Internet to look up farming or business information (Ferrer et al., 2003). When comparing age and likelihood of adoption of the Sugarcane Burn Planner, there are not enough respondents in each age group to make a definitive statement, but the youngest age group (36-46) all responded with “Very Likely” or “Likely”, while the older two age groups (47-56, 57-66) had responses of “Moderately Likely”. This would follow the expected pattern of younger farmers being more apt to adopt new technology, but again, cannot be statistically supported. In this thesis, seeking out information from Internet sources is defined by the respondents’ indication of how often they use the Internet to find “Information from research institutes”, “Information on farming best practices”, and

“Information on new farming technologies”. A similar pattern is seen when comparing age and seeking out farming business information via the Internet, with the younger age group respondents only reporting measures of “Often” and “Sometimes” and the older age groups including “Seldom” responses (Table 4.1).

Table 4.1 Cross-tabulation of Age (Q7) and Seeking out Information (Q17)

Age Group	**Sample Size (n)**	**% Response = “Often”**	**% Response = “Sometimes”**	**% Response = “Seldom”**
36-46	5	60.00%	40.00%	0.00%
47-56	10	46.67%	43.33%	10.00%
57-66	3	66.67%	22.22%	11.11%

Farming Experience. “Years in your decision-making role” and “Years in the sugarcane industry in any role” quantify farming experience in this study, and the results show that the data is negatively skewed with the majority of respondents being in their decision-making role and in the sugarcane industry for more than 16 years (Figure 4.3). Ford and Babb (1989) previously reported that farmers with greater experience sought out information provided by extension services more than those with less experience, while Schnitkey et al. (1992) found the opposite to be true. This study cannot support either Ford and Babb (1989) or Schnitkey et al. (1992), but it can speak to what type of information all respondents seek out via the Internet, of which mostly have more than 16 years of experience. Figure 4.4 compares how often all respondents seek out farming information via the Internet, showing that, across the board, the Internet is used fairly often for these applications, the most common of which is the look up of “Information on farming best practices”. Since the majority of respondents have many years of experience, it can be theorized that those with high experience levels frequently use the

Internet to look up farming best practices, although it cannot be compared to the practices of farmers with less farming experience.

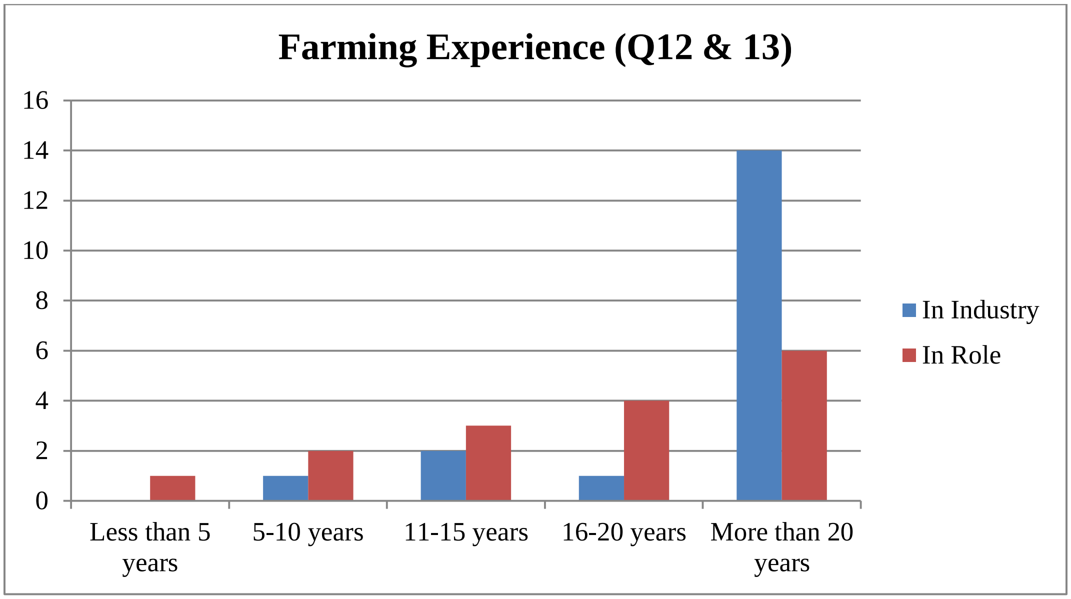

Figure 4.3 Response Total for Farming Experience (Q12, Q13)

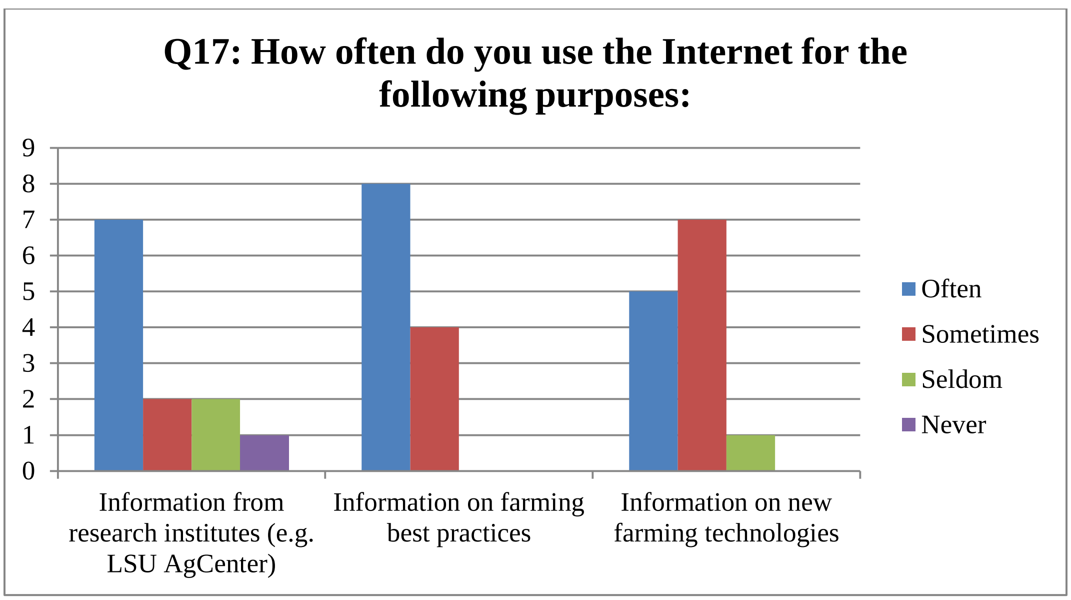

Figure 4.4 Response Total for Seeking out Information (Q17)

Education. Batte (2005) found the presence of post-high school education as the most impactful demographic characteristic when looking at the adoption of computers, but, as seen in Figure 4.5, all survey participants in this study have at least a high school education so it could not be compared directly to Batte’s study. Overall, no statistical correlation was found between the education level and the likelihood of adoption of the Sugarcane Burn Planner and no obvious patterns are seen in the cross-tabulation of variables (Table 4.2).

Table 4.2: Cross-tabulation of Education Level (Q8) and Likelihood of Use (Q4)

Education Level	**Sample Size (n)**	**% Response = “Very Likely”**	**% Response = “Likely”**	**% Response = “Moderately Likely”**
High School/GED	2	0%	100%	0%
Some College	5	40%	40%	10%
Associate’s Degree	1	0%	100%	0%
Bachelor’s Degree	4	25%	25%	50%
Graduate Degree	7	57%	43%	0%

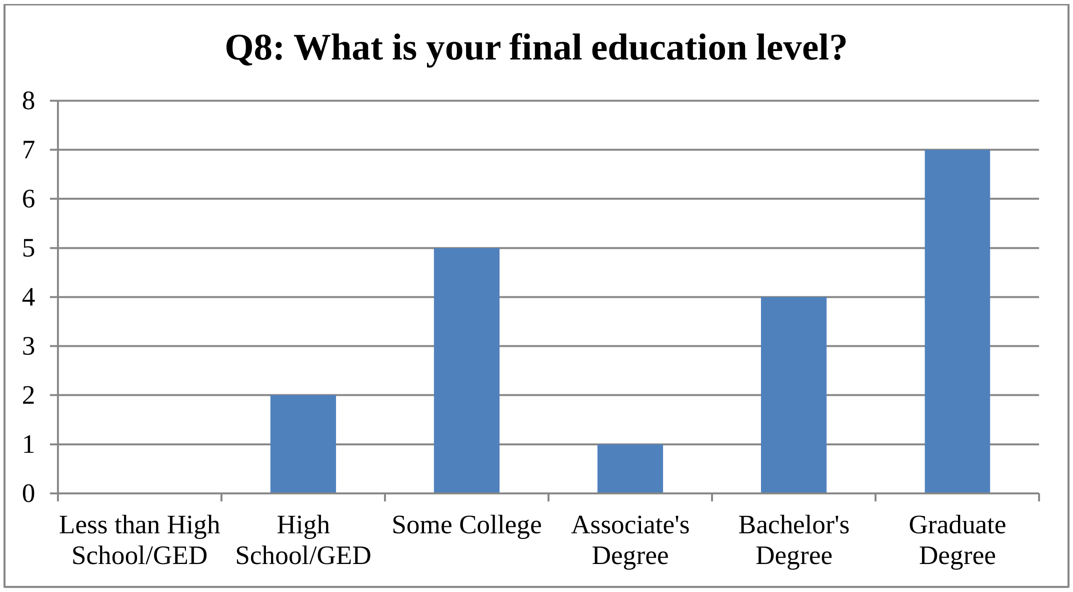

Figure 4.5 Response Total for Education Level (Q8)

The idea of good “communication behavior”, as discussed in “Publicly funded agricultural,” 2002) is a characteristic of individuals as being socially open farm managers who seek information, which may or may not be due to receiving more formal education. The cross-tabulations between education and measures of seeking out information via the Internet (Table 4.3) show that those with a graduate degree tend to seek out information more often, possibly due to connections with the LSU AgCenter research division. This doesn’t mean that those with a graduate degree are necessarily more “socially open” farm managers, but it may reflect their value of up-to-date research since they have experience with research projects conducted at the graduate level.

Table 4.3 Cross-tabulation of Education Level (Q8) and Seeking out Information (Q17)

Education Level	**Sample Size (n)**	**% Response = “Often”**	**% Response = “Sometimes”**	**% Response = “Seldom”**
High School/GED	2 (x3 questions)	16.67%	66.67%	16.67%
Some College	5 (x3 questions)	46.67%	40%	13.33%
Associate’s Degree	1 (x3 questions)	100%	0%	0%
Bachelor’s Degree	4 (x3 questions)	25%	58.33%	16.67%
Graduate Degree	7 (x3 questions)	76.19%	23.80%	0%

Farm Size. When technology requires a monetary investment, farm size often plays a role in determining adoption because technology, like a computer or software package, is usually a bulk purchase (meaning it is not divisible or cost less for smaller farms). Bulk purchases sometimes make more financial sense for larger farms because it benefits more acres or a larger operation. The Sugarcane Burn Planner differs in that it is accessible online free of charge, but the question asking if farm size influences the adoption of the application was still asked after reviewing the statistics provided by the

USDA NASS on computer usage for farm business and Internet access based on farm size by annual income because the percentage is generally higher as income increases (Figure 4.6).

Farm size in this survey was measured by number of burns (Q14) and acres (Q15). The average number of burns conducted annually was 27 and the average acres of sugarcane farmed was 1583.94 (Table 4.4). No indication that a smaller or larger sugarcane farming operation is more likely to adopt the Sugarcane Burn Planner application can be seen in the cross-tabulations to likelihood of adoption. The only indication that farm size plays a factor into the application adoption is one free response answer, explaining:

> "Small plot research at St. Gabriel research station. Burning small plots would be hard to plot each time. Larger fields could be plotted"

This is assumedly a rare scenario where the research plots are significantly smaller than normal sugarcane operations and broken out into separate areas, which would make using the application more difficult and take more time. Theoretically, farm size should only be an important indicator if all fields were equal distance from the same number of potentially affected neighboring communities. A smaller field that is closer to a residential neighborhood and school would probably be more likely to utilize a smoke mitigation tool than a large field in a very rural area. If both fields had the potential to impact the same number of people, the larger field may be more likely to utilize the tool because they would expect more smoke and ash. Without holding one of these variables constant, it is hard to tell if farm size is an important factor in application adoption.

Farm Computer Usage: by Economic Class [1], Type of Farm, Region and United States, 2007, 2009, and 2011

Region	Farms					
	Using Computers for Farm Business			With Internet Access		
	2007	2009	2011	2007	2009	2011
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
South [4]	30	29	31	52	55	58
$1,000-9,999	24	22	25	50	52	55
$10,000-99,999	33	35	36	51	56	59
$100,000 & Over	55	58	55	66	69	70
$100,000-249,999	48	50	43	60	65	62
$250,000 & Over	61	65	66	70	72	75
Crop Farms	30	29	32	50	54	59
Livestock Farms	30	29	30	53	55	58

Figure 4.6 USDA NASS Farm Computer Usage

Table 4.4 Survey Respondents' Farm Sizes

	Mean	**Median**	**Mode**	**Range**
Annual # of Burns	27	22.5	15	4-50
Acres of Sugarcane	1583.94	1100	300	290-5000

4.3 Technology

The survey participants are more technologically savvy as a group when compared to all farmers in Louisiana, probably due to the survey being distributed electronically and hosted online. All respondents indicated having regular access to the Internet, the majority owns 3 or more Internet-accessing devices, and 89% use at least one of these devices in the field. This explains why the group also finds the Internet more important to their farm practices, with 66.67% believing it to be "Very Important" (Figure 4.7), which is much higher than a previous study that found only 22% of farmers believed the Internet improved their farming business (Warren, 2004). The USDA NASS statistics on Farm Computer Usage and Ownership report Louisiana farmer computer access as 60%, Internet access as 53%, and computer usage for farm business as 28%, all of which are slightly below the US farm averages and significantly lower than the survey sample (USDA NASS, 2011).

The USDA NASS statistics show a wide gap between those who have computer and Internet access (53%) and those who use a computer for farm business (28%), suggesting that it is not a lack of technological infrastructure or knowledge that prevents the use of the computer/Internet to improve farming practices and business productivity (USDA NASS, 2011). Recent literature supports this same idea stating that the main obstacle of IT adoption in agriculture has shifted from lack of technical knowledge to lack of seeing or understanding the benefit of using technology (Burke, 2010; Gelb and Voet, 2009). The high likelihood of adoption of the Sugarcane Burn Planner measured by this survey demonstrates how this is not a major obstacle because the known causes for not seeing the benefit of use are addressed in the following ways:

- *Educational restraint (Öhlmér, 2007)* – All survey participants have at least a high school education and many have a college degree. The process and information provided by the Sugarcane Burn Planner is easy to understand and does not pose a comprehension issue.

- *Public training lagging behind technological innovations (Gelb and Voet, 2009)* – The video that accompanied the survey acted as a first training step for understanding the application and, if fully implemented, the Louisiana mitigation program would most likely incorporate application instructions into their existing training sessions.

- *Reliance on intuition for repeated processes (Öhlmér, 2007)* – Even though farmers have burned many times before, knowing the geographic location of all the sensitive sites, the changing wind direction, and the projected smoke plume distance is a dynamic challenge, making intuition less reliable. Also, having proper burn documentation is a very important part of the process, which is not accomplishable through intuition alone.

- *New technology has poor usability (Alvarez and Nuthall, 2006)* – As previously discussed, the application received high agreement rankings with "Easy to Use*"* and "Intuitively Designed*"*.

- *Developers do not address the real problem (Alvarez and Nuthall, 2006)* – The 'real problem' has already been defined by the LSU AgCenter researchers and is well addressed in the current paper process; therefore, the digital version of the same process is a solution for the 'real problem' as well.

- *Farmer does not know how to apply it to his/her specific needs (Briggeman, 2010)* – Through the combination of the very specific application design for Louisiana sugarcane smoke mitigation and the training on how it should be used, farmers will know how to apply this application to their needs.

In developed countries, the main question is changing from if a computer with Internet access is available to what applications are actually being used (Taragola, 2010). The theory holds true from the perspective of this research, considering all respondents have computer/Internet access and the frequency of use of other Internet applications was the most common variable found to be significantly correlated with adoption, usability, and usefulness of the application. The results of survey question #17 (Figure 4.8) show that the Internet is used most frequently to look up weather forecasts and information on farming best practices, while it is least utilized for recruitment of personnel and entertainment/social networking, similar to Burke's (2010) study that found that half of their SME agribusiness survey respondents had never used email, blogs, podcasts, or instant messaging. Although using the computer/Internet for social and entertainment activities has the potential to act as a technology teaching tool (Warren, 2004), the results of this study show that other Internet applications that are accessed more frequently play a bigger teaching role. Overall, the Internet is being used fairly often, which enforces Batte's (2005) results where Internet-based applications were identified as one of the top computer tasks by 73.5% of farmer respondents.

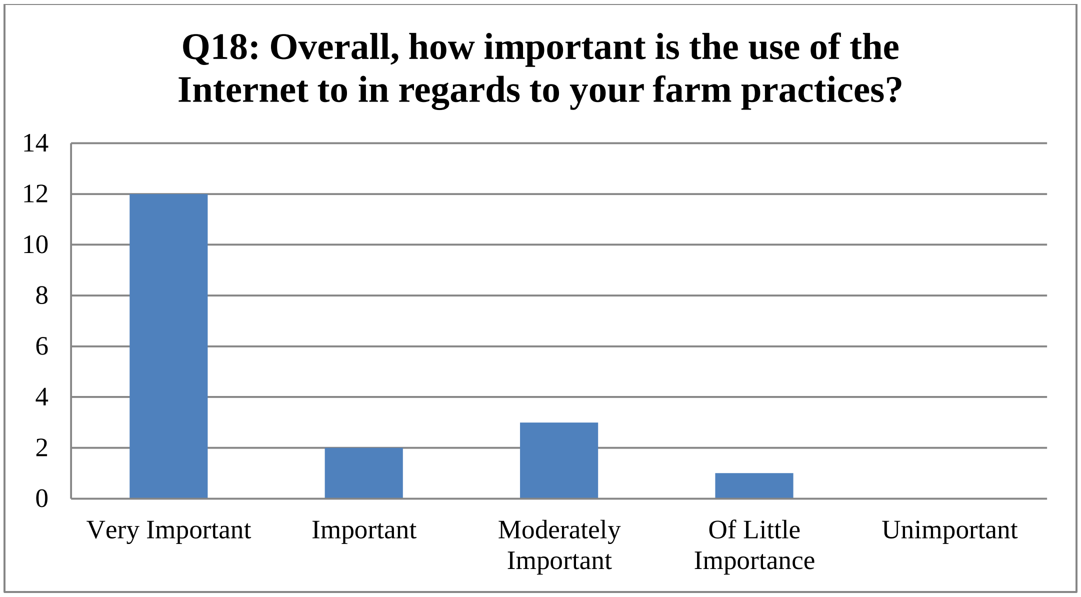

Figure 4.7 Response Total for Internet Importance (Q18)

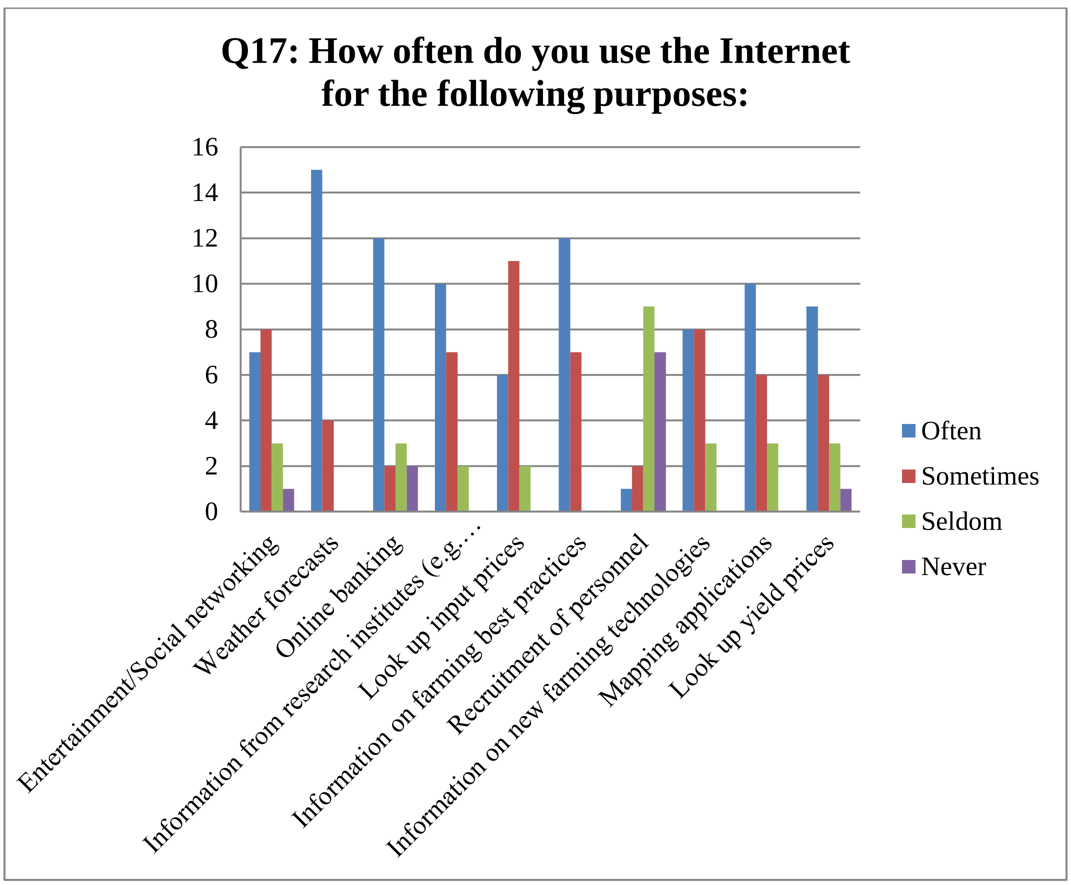

Figure 4.8 Response Total for Frequency of Use of Other Internet Applications (Q17)

4.4 Community

Location and Geographic Awareness. The reason sugarcane burning mitigation programs exist is to protect surrounding areas from the adverse effects of smoke, making proximity to community an important and influential factor when deciding how involved to be in the mitigation program. The addresses of the survey participants were plotted and satellite images of each location were analyzed at a 5-mile buffer scale and at a smaller scale to analyze location variation. The images are not included in this text to protect the privacy of the survey participants. When asked how far their sugarcane fields are from smoke sensitive areas (Q21), all respondents said "Very Close (<1 mile)" or "Fairly Close (1-5 miles)", and the analysis of the satellite images confirms that fields are often positioned near residential or business areas. But each location is unique and has obvious areas that they are probably very aware of, such as one location being very near a major road or another that is located a few miles southeast of a highly populated area. There are also locations where farmers that may be less aware of how many people or businesses their burns can potentially affect because, like some of the survey participants, their fields are located in an area with more evenly spread population in all directions or near a wide river with heavily populated areas located on the opposite bank. Location and personal geographic awareness cannot be ignored in this analysis since sugarcane burning is a community issue and is inherently geographic.

A buffer analysis totaled the number of people living within 5 miles of each field address, which is the average distance traveled by burn smoke plumes before dissipating. This number was then compared to answers given to survey question #22:

"Approximately how many people do you think live or work within a 5-mile radius of your sugarcane burns?". As seen in Figure 4.9, the approximations given seriously underestimate the actual census nighttime population numbers, but that does not necessarily mean that they are unaware of their surroundings. To begin with, this is a very difficult question to answer because the respondent would need to mentally consider all population totals 5 miles in every direction when approximating the number of people in even a small area is a very difficult task. Also, some people may have interpreted the question as how many people are affected within a 5-mile distance from the field, considering that burns only affect people in the direction of the wind, even though this number can change as quickly as the wind direction. Because of all the uncertainties surrounding this question, no concrete conclusion can be made about the survey participant's awareness of their surrounding community, but it may be useful to add population totals within a buffer or within the projected smoke plume to the Sugarcane Burn Planner application analysis to provide a better sense to the farmer of the number of people nearby.

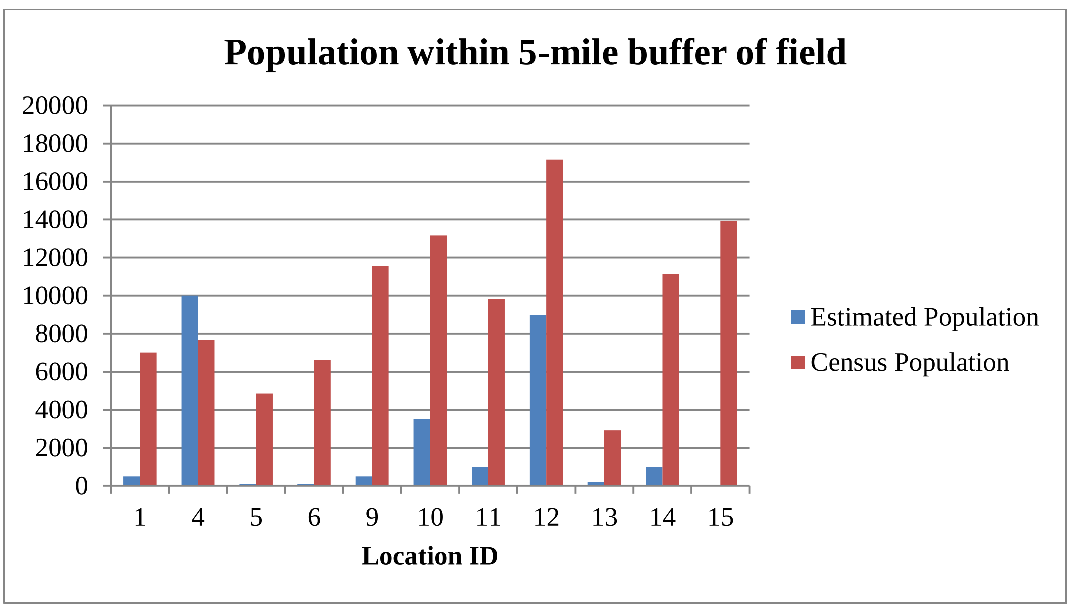

Figure 4.9 Perceived Number of People Affected (Q22) vs. Census Nighttime Population

Mitigation Program Assessment. The survey questions related to the Louisiana smoke mitigation program asked how frequently they completed each step of the process (Q25), how many training sessions were attended (Q23), how long ago they attended a training session (Q24), if the program is effective (Q26), and if the program is important (Q27). The only mitigation program variable significantly correlated to adoption of the application was the number of training sessions attended, but the information gained from these questions still has great value as no official program assessment has ever been conducted since its inception.

Those who are new to the voluntary smoke mitigation program in Louisiana attend a 2-hour training session led by personnel from the LSU AgCenter and the Louisiana Department of Agriculture and Forestry that cover the steps involved in the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting.* At the end of the 2 hours, participants are administered a test and, upon passing, are sent a letter and card in the mail denoting their status as a "certified burn manager". Certification expires every 5 years and the recertification process is much shorter, consisting of watching a 15-minute video refresher. All but one survey participant has attended a training session (for certification or recertification) in the past 5 years, making them active participants in the program.

Although it is recommended that all 7 steps be completed every time a field a lit, the results show that this ideal is not met (Figure 4.10). The most frequently completed steps are "Step 1: Identify Areas Sensitive to Smoke and Ash", "Step 2: Obtain Fire Weather Forecast", "Step 4: Determine Smoke Category Day", and "Step 6: Determine

Trajectory of Smoke and Ash Plume". The least common steps completed are "Step 3: Develop a Prescribed Burn Plan", which is the step involving writing all of the information on the document so it is recorded, and "Step 7: Evaluate the Prescribed Burn Results", which is the only step that takes place after the burn has finished. The application can greatly help with these less frequently completed steps since the output from all the other steps is easily saved or printed. It is also interesting to note that determining the projected smoke direction is done more often than determining the smoke distance, probably resulting from knowing the direction of nearby sensitive areas and not being concerned as much with sensitive areas that are farther away.

As a whole, those surveyed believe the program to be effective and important (Figure 4.11, Figure 4.12). The similar unofficial sentiment, as described by Kenneth Gravois from the LSU AgCenter (personal communication, March 28, 2013), is that mostly everybody realizes that burning is a "privilege and not a right" and have realized the positive effect of the program through a drop in smoke complaints. The program is able to remain voluntary due to regular participation and proven program benefits and the lack of red tape is appreciated by the farming community, but they are always looking for ways to improve upon the process and make it more accessible.

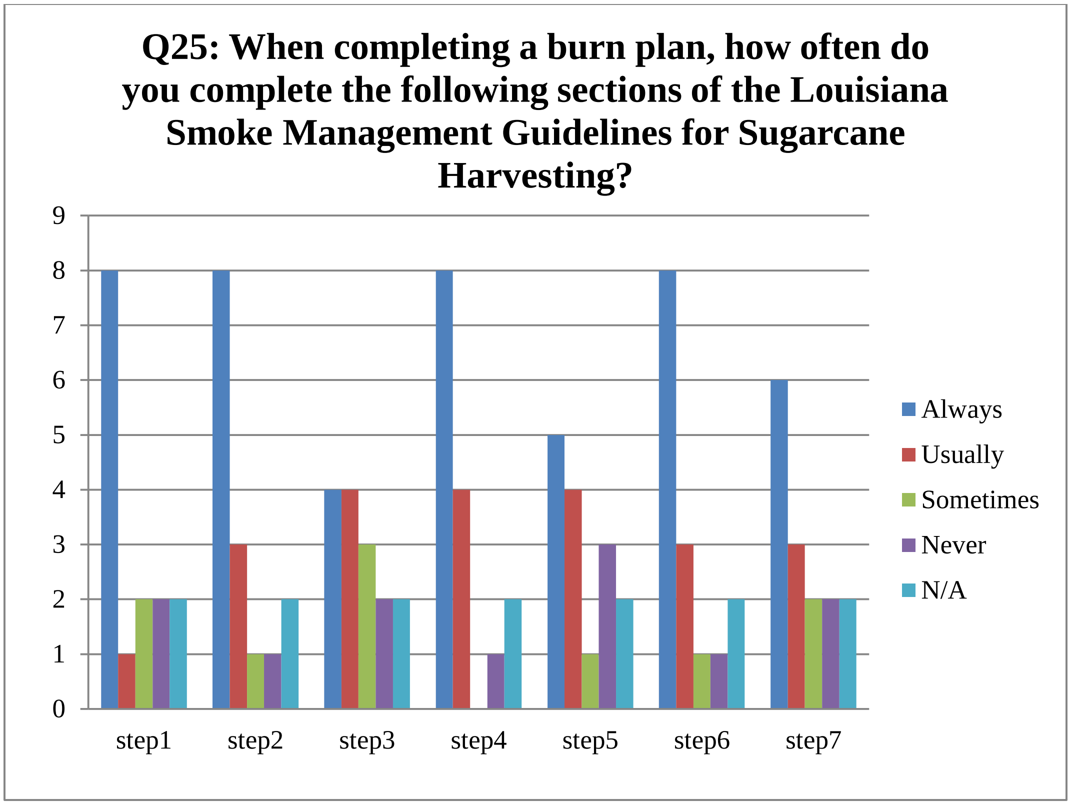

Figure 4.10 Response Total for Frequency of Mitigation Program Step Completion (Q25)

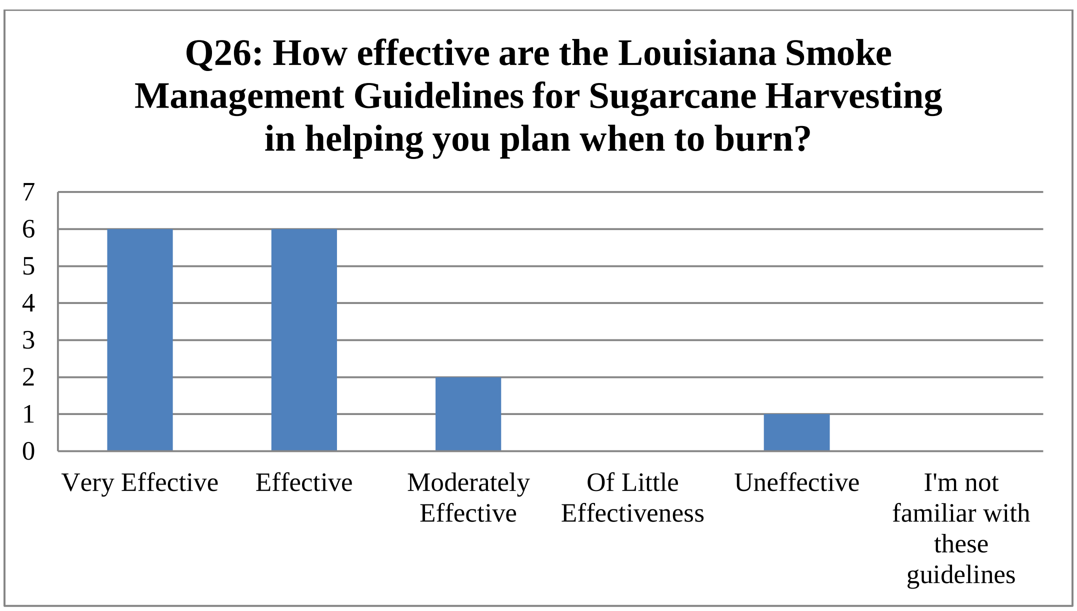

Figure 4.11 Response Total for Program Effectiveness (Q26)

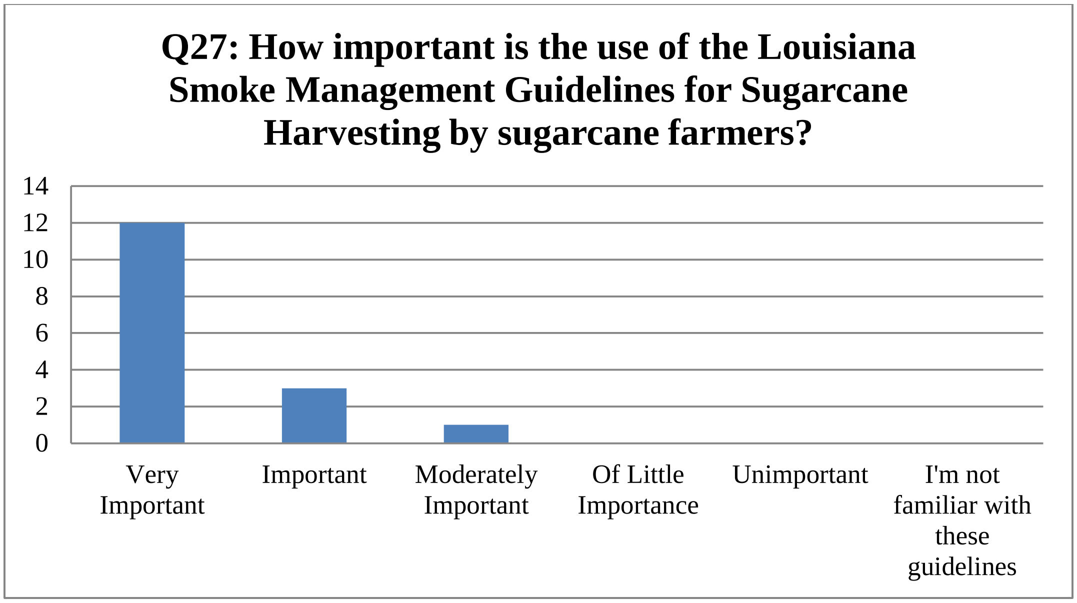

Figure 4.12 Response Total for Program Importance (Q27)

4.5 Relationships among Non-Adoption Variables

When variables relating to the adoption, usability, and usefulness of the application are taken out of the equation, the dependent and independent roles of the other variables change. The variables related to technology and the community become the dependent components in order to analyze if they are related to certain farmer or farm demographics to answer questions such as, are older farmers more technologically challenged? Or do farms that burn more frequently participate more in the smoke mitigation program?

In order to answer these and other related questions, two indices were developed: the Technology Index and the Mitigation Program Index, calculated as:

Q17: Use of other internet applications (sub-index score of 0 – 5) * .25

+ Q18: Importance of Internet to farm practices (score of 0 – 5) * .25

+ Q19: Total of Internet-accessible devices owned (score of 0 – 5) * .25

+ Q20: Using a computer in the field (score of 0 or 5) * .25

Total * 10 = Technology Index ranging from 0-50

Q25: Burn Plan Completion (sub-index score of 0 – 5) *.33

+ Q26: Effectiveness of program (score of 0 – 5) * .33

+ Q27: Importance of program (score of 0 – 5) * .33

Total * 10 = Program Mitigation Index ranging from 0-50

The Technology and Program Mitigation Indices represent the technological use and knowledge and the involvement in the current mitigation program, respectively. Each variable that contributes to the Technology Index is given a weight of .25 and each variable contributing to the Program Mitigation Index is given a weight of .33 to standardize the two indices so that they range from 0 to 50 and can be compared. Question #20, a binary variable included in the Technology Index, does not have possible scores of 0 or 1 because that would give equal value of using a computer in the field to ranking the Internet as “Unimportant” to farm practices, which is obviously not equitable when measuring technological use and knowledge. If a respondent uses a computer in the field, they receive a value 5 for that component of the Technology Index, which is more equitable to ranking the Internet as “Very Important” to farm practices.

The indices were compared to four demographic variables: age, education, farming experience, and farm size. The results of plotting the demographic variables against the indices can be seen in Figures 4.13-4.18, which do not show many clear patterns. The Education Level vs. Indices graphical representation shows an inverse normal distribution, but this is somewhat misleading as the average index value for those receiving an Associate's Degree only represents one respondent. The only other visible pattern is an increase of farm size (by number of acres and number of annual burns) associated with increased technological use and knowledge and increased involvement in the mitigation program. More respondent data is needed to improve this analysis, but overall the data available shows weak association between demographic data and technological and program involvement variables.

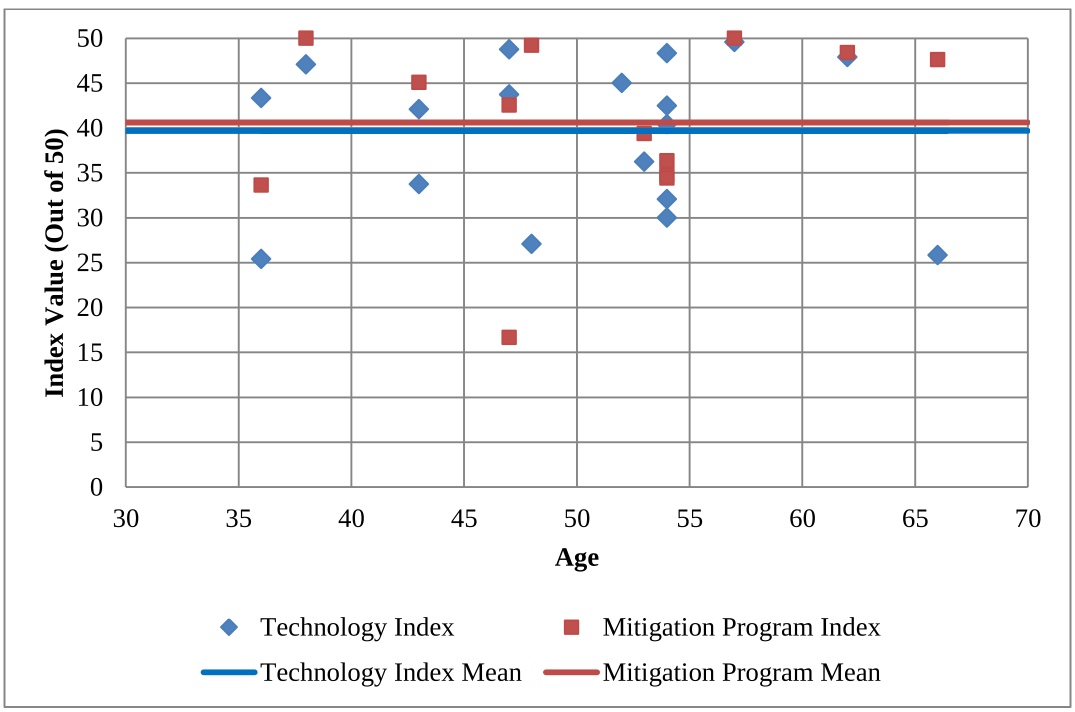

Figure 4.13 Age vs. Indices

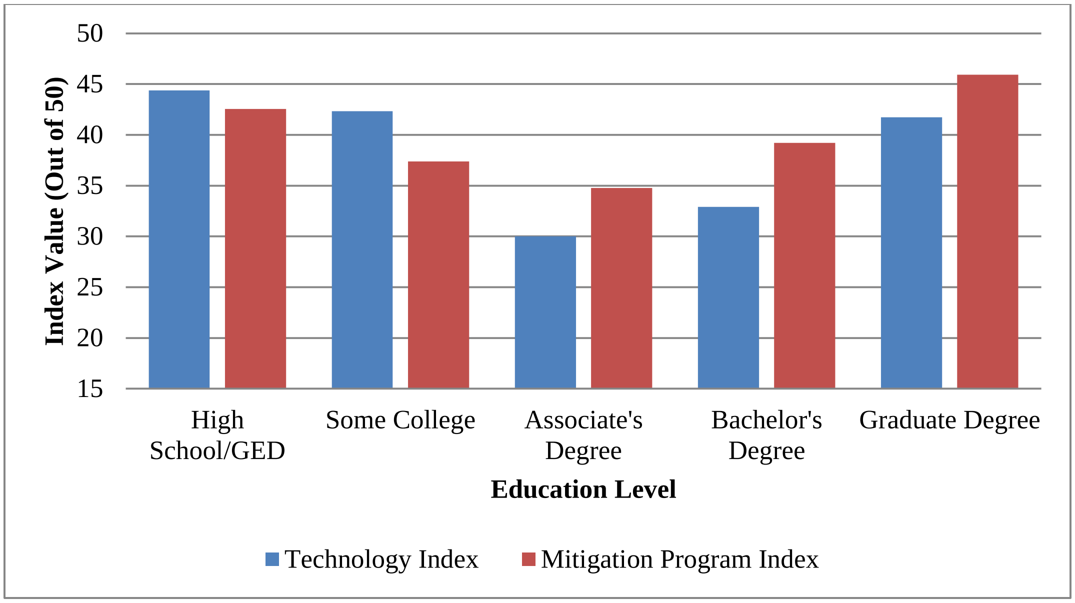

Figure 4.14 Education Level vs. Indices

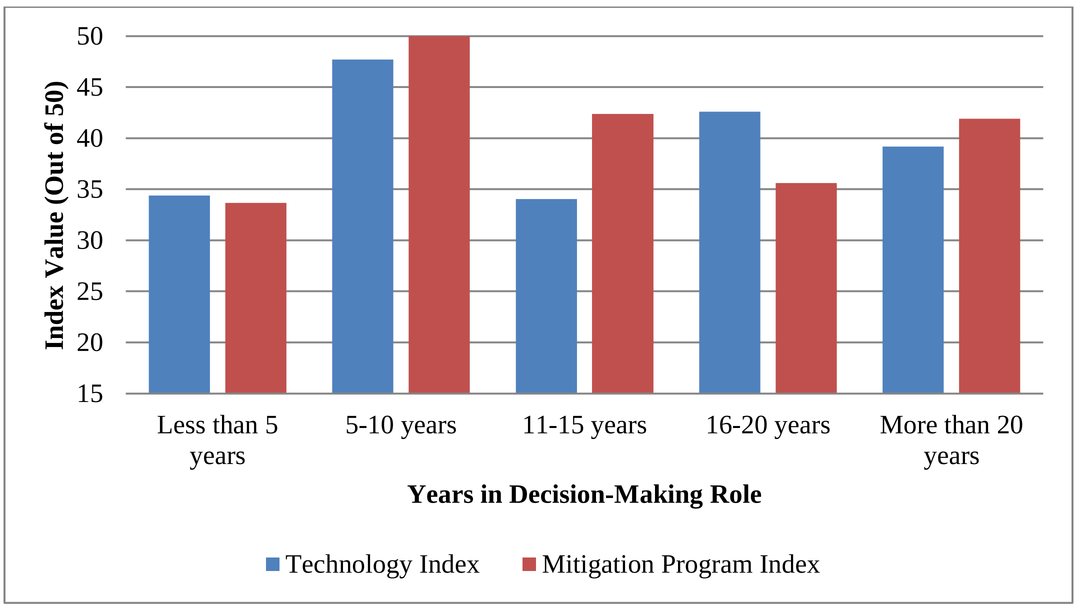

Figure 4.15 Years in Role vs. Indices

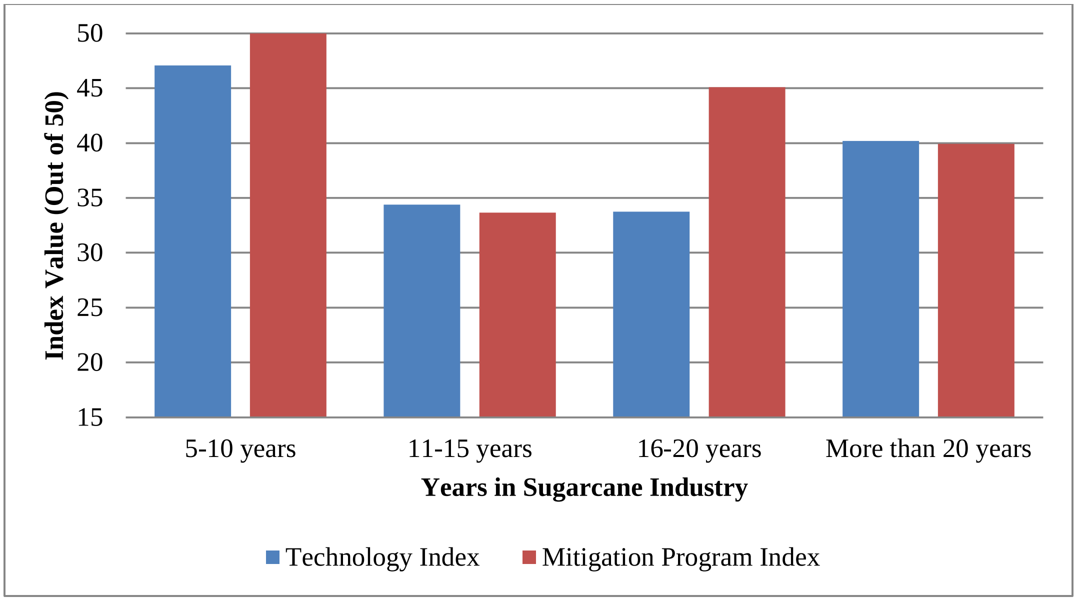

Figure 4.16 Years in Industry vs. Indices

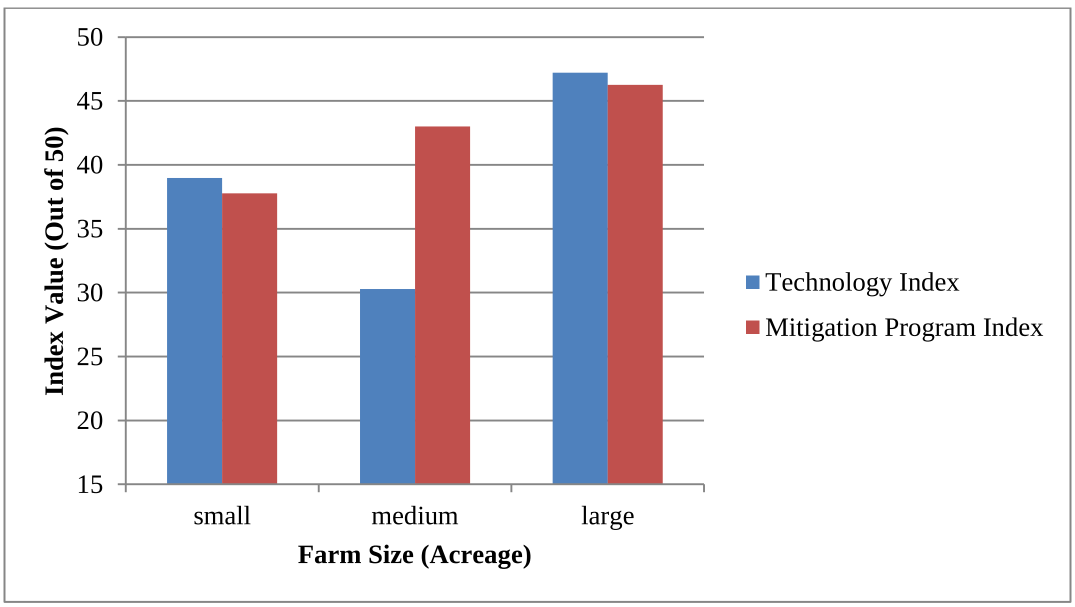

Figure 4.17 Sugarcane Acres vs. Indices

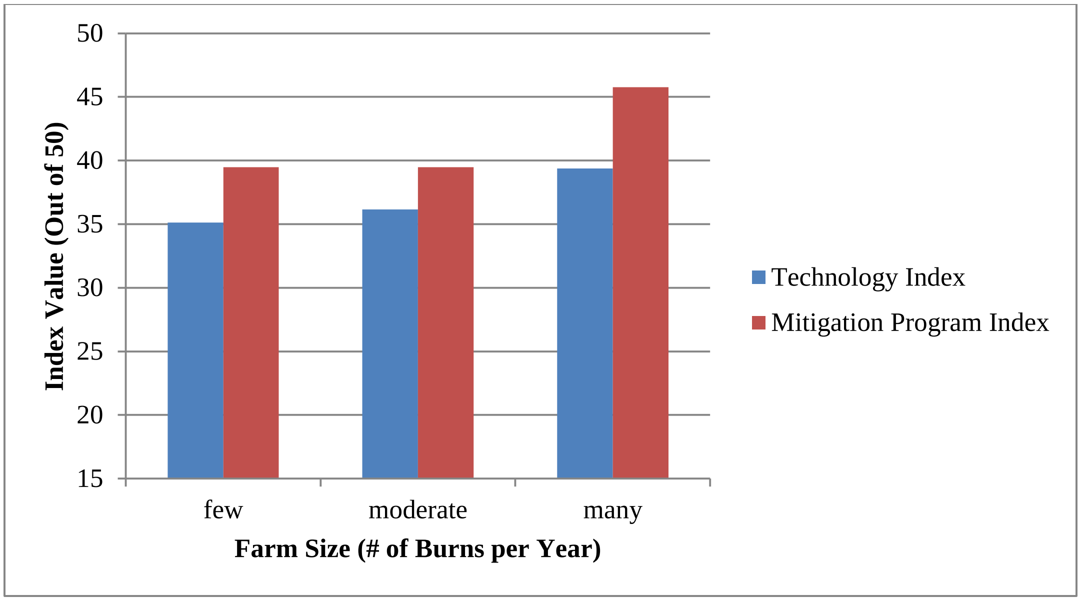

Figure 4.18 Number of Annual Burns vs. Indices

CHAPTER 5

CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

5.1 Addressing the Research Questions

The results of this study have answered the research questions in the following ways:

1. What demographic, community, and technology characteristics are related to the perceived usefulness, usability and adoptability of the introduced online application and how does it compare to patterns shown in the literature as related to computer/Internet adoption?

The biggest difference between this study and others is that demographic variables did not play a part in predicting any usability or adoption patterns. There are a couple possible reasons that may explain this finding. First, it could be that the use of the computer/Internet is more widespread today when compared to the years studies were previously conducted or it could be a limitation of the small sample size that did not provide a very wide range of demographic characteristics to analyze. Also, since the Sugarcane Burn Planner application does not require up-front investment in the form of money or extensive training, demographic variables do not dominate the adoption decision-making process. If a tool is easy to use, easy to understand, provides valuable information, and does not require additional investment, it is more likely to infiltrate all levels of age, education, farming experience, and farm size. A farmer's perception of how the Internet and related technologies benefits their business and how often it is already utilized becomes more of a predictor of if they are likely to adopt a new application.

Technology variables were the most significantly correlated to adoption in this study. Michailidis (2006) also studied the farmers' value of the Internet stating:

> It appears that the value of the Internet is not necessarily in replacing other means for sourcing information, such as about weather. Some value comes from making processes more efficient, as in the use of electronic banking services or ordering goods online. Some value comes from providing better access to information (especially technical information). (p. 92)

Although the Sugarcane Burn Planner application directly replaces a process that produces the same information, the recognized value, similar to Michailidis's (2006) finding, comes from making the mitigation process more efficient and accessible and this is enough to motivate potential users to adopt it. The studies of Ferrer et al. (2003) and Warren (2004) concluded that farmers generally did not believe the Internet to have high importance to their businesses unlike the results of this study, with 12 out of 18 respondents saying that the Internet is "Very Important" to their farm businesses. The unusually high importance given to the Internet by this study's respondents may be a reflection of the study limitation of having a self-selected sample likely to be more comfortable with technology. Batte (2005) found that computer usefulness evaluations were higher for farmers who used the Internet to gather information, similar to this thesis which found using the Internet to look up information (from research institutes, for farming best practices, new farming technology, and yield prices) is significantly related to the adoptability of the Sugarcane Burn Planner. Using a device in the field was not found to be significantly related to adoption in this study while it made farmers 2.1 more likely to adopt remote sensing imagery in Larson et al.'s (2008) study.

Community variables, including the proximity of the field to the community and level of buy-in to the current mitigation program, had a moderate influence on the likelihood of adoption of the application. The number of training sessions attended, perceived program effectiveness, perceived program importance, distance from surrounding community, and the estimated number of affected people within 5 miles are all variables that were found significantly related to usability and usefulness measures. This is the first study to use community variables such as these in an agriculture technology adoption study. They were included because of the unique nature of agriculture burning - where neighboring people and places outside the farm play a critical role in the farmers' burn management decision-making process.

Caution is given when attempting to generalize a study like this one to other regions due to high geographic variability in agriculture, but is acceptable if regions have similar characteristics like crop type or local extension efforts (Putler and Zilberman, 1988; Burke, 2010). Since demographic characteristics are not influential in the adoptability of the Sugarcane Burn Planner, it is likely to have high adoptability rates among sugarcane farming populations in other states if they have similar patterns of technology use and community awareness.

2. Do any other relationships exist between the demographic, technology, and community variables?

When the independent demographic variables are graphed against technology and community indices, very little association can be seen between any of these characteristics. This is surprising since many past studies have reported strong correlations between age, education, farming experience, and farm size with perception and use of technology. The comparison of farm size measured in acres and in number of burns per year with each index shows a subtle pattern; as farm size increases, the indices tend to also increase. It makes sense that farmers who have larger farms and burn more often would be likely to have higher participation in the smoke mitigation program as their farm practices likely affect more sensitive sites. The Technology Index increasing with farm size is probably consistent with the typical positive relationship of computer and Internet adoption in previous studies because the index is based on computer and Internet possession and use. Although this research did not find farm size significantly correlated to the adoption of the Sugarcane Burn Planner, the idea that it is correlated to computer and Internet adoption is still supported by this comparison to the Technology Index. Again, the small sample size may be preventing clear patterns from emerging, but it does validate that the variable groups are generally independent from one another in this study.

3. Even though the introduced application would presumable be useful in sugarcane burning smoke mitigation, would it actually be used? Is there an opportunity for similar tools to be developed in this industry space?

Sugarcane farmers were found to be likely to use the Sugarcane Burn Planner application with 17 out of 20 respondents indicating they are "Likely" or "Very Likely" to use it. Some of the positive comments seen below back this conclusion:

> "I think that this new method simplifies the current sugarcane prescribed burning plan"

> "It provides a clear picture of the impact your burn will have on the surrounding areas. I like the projected plume feature. And also that it exactly marks your map"

> "This guide will be extremely helpful and take a lot of the guess work out of the equation"

> “We as producers have a need for this kind of tool. This can help in identifying problems which can come up during a prescribed burn. I feel it would be very helpful to my operation”

> “I think that this planner is well thought out and will be really simple to use, as well as being easier than using paper maps and such and the smoke plume feature is really nice”

These positive adoptability measurements mirror results found in the Car et al. (2012) study, where they tested an SMS phone system to replace a full irrigation Decision Support System (DSS) that had poor uptake even though it had proven model accuracy and water savings. They concluded that the more sophisticated systems that produced comprehensive scheduling support had interfaces that were too difficult to navigate, did not provide the appropriate information for end users, and were time consuming to use. The most appreciated features of the SMS system were the simplicity of use, advice, and prompting effect of receiving a text message. The Sugarcane Burn Planner is similar to their SMS system solution, as it simplifies the process, is faster, outputs the appropriate information for sugarcane farmers, and provides advice while allowing them to make the ultimate decision of when to burn, which incorporates farmer intuition. If future development follows the same concept of simplification and decision support by means of reducing uncertainty (and not by attempting to capture the full complexity of a farm system), adoption is more likely to occur (McCown, Brennan, and Parton, 2006). Farm Management Research, a field composed of agricultural modelers with an economic paradigm, has disconnected from pragmatic farm decision making. McCown, Brennan, and Parton (2006) explain how agricultural scientists in this field originally concentrated their efforts on on-farm research but the field has gradually been taken over by theory-based economic analysis and the field’s research lost its relevance to its ultimate goal -

farm decision making. The lesson learned is that if academic research endeavors and/or extension and outreach aim to support farmer decisions, the 'field work' involved is to understand the farmer's preferences and decision-making process. The most sophisticated system is not always the best; the most all-inclusive system is not always the best; and the system that provides the most information is not always the best. Supporting farm decisions means supporting farmers, making the human element a top priority.

Farmers in the sugarcane industry are following the overall U.S. trend of increased computer/Internet use and there is a clear opportunity for a user friendly GIS-based application in agricultural smoke mitigation efforts. The sugarcane farmers questioned are comfortable with computer/Internet use and it is the usability of the application and the frequency that they already use Internet applications and Internet-accessing devices that motivate their adoption of the Sugarcane Burn Planner. I hypothesize that farm managers' adoption of technology will not lag as far behind when compared to other SME business managers as more mobile and easy-to-use applications are developed that provide advice to be used in conjunction with intuition as this better fits their manual labor job lifestyle and preferred intuition-driven decision-making style. The Sugarcane Burn Planner application leads toward this development direction and can be further improved upon in subsequent versions with these ideas in mind.

5.2 Future Research

The feedback about the Sugarcane Burn Planner application received from the survey is very valuable in suggesting future direction of development. The most common suggestion is to make the application mobile so that it can easily be used in the field. As it is now, the Sugarcane Burn Planner can be used on a mobile device, although some design elements could be further customized for the smaller screens to improve the overall mobile experience. Other potential improvements to the application include finding consistent fire weather forecasts and making them more accessible in the application, building a database to capture the final burn plan information, setting up a network between the Sugarcane Burn Planner and local fire departments so that they are automatically notified when a burn is planned, highlighting the most sensitive nearby areas on the map, providing a calculated total population number living or working within the projected smoke plume area, and updating to a more sophisticated smoke plume model for increased prediction accuracy. The statistics reported here relating to technology adoption rates in agriculture can be improved upon with a larger sample size that includes a more diverse group of participants. This could be accomplished by a mailed survey to prevent the sample from being self-selected by the technologically savvy members of the population. Other possible ways to increase the diversity of the sample would be to include farmers outside of the sugarcane industry who have similar burning issues or compare farmers from a different sugarcane growing state to those form Louisiana. Since this is the first study to relate these specific community variables to the adoption of technology in agriculture, there is room to expand upon how a sugarcane farmer's location in regards to the farm's proximity to community and geographic awareness affects how they make burn-related decisions.

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APPENDIX A – EXISTING SIMILAR TECHNOLOGIES

Table A.1 Analyzed Tools and Applications

From U.S. Forest Service and National Wildlife Coordinate Group Lists:	
CALPUFF	http://www.src.com/calpuff/calpuff1.htm
First Order Fire Effects Model (FOFEM)	http://www.firelab.org/science-applications/fire-fuel/111-fofem
Smoke Impact Spreadsheet (SIS)	http://www.airsci.com/SIS.htm
Simple Approach Smoke Estimation Model (SASEM) 4.0	http://www.azdeq.gov/environ/air/smoke/fires.html
Fire Emission Production Simulator (FEPS) 1.0.0	http://www.fs.fed.us/pnw/fera/feps/index.shtml
Ventilation Climate Information System (VCIS)	http://plone.airfire.org/wfdss-aq/help/vcis
Rapid Access Information System (RAINS) / BlueSky	http://www.airfire.org/bluesky/
From State Programs:	
Florida Forest Service App	http://www.floridaforestservice.com/fire_weather/spot/index.html
Spot Weather Forecast	http://www.floridaforestservice.com/fire_weather/spot/index.html
CANSAC	http://www.arb.ca.gov/smp/techtool/techtool.htm
Interagency Real Time Smoke Monitoring	http://www.arb.ca.gov/smp/techtool/techtool.htm
California Emission Estimation System	http://www.arb.ca.gov/smp/techtool/techtool.htm

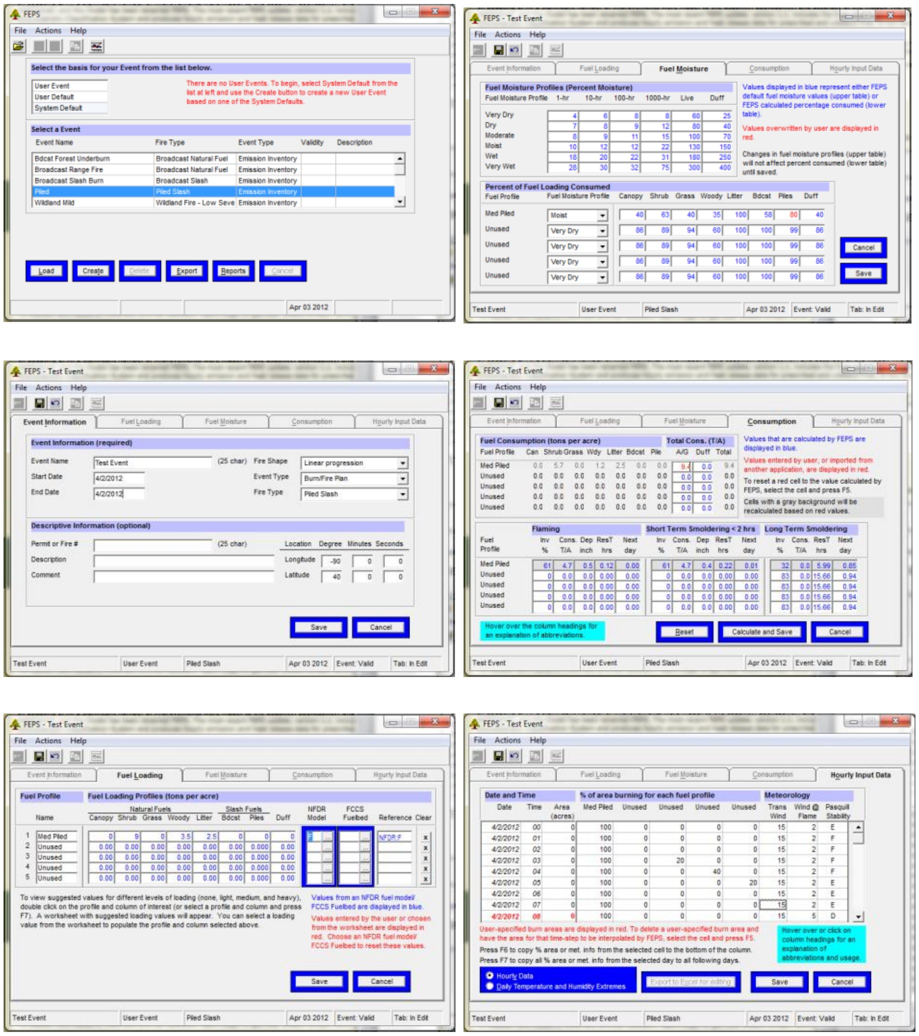


Figure A.1 Fire Emission Production Simulator (FEPS)

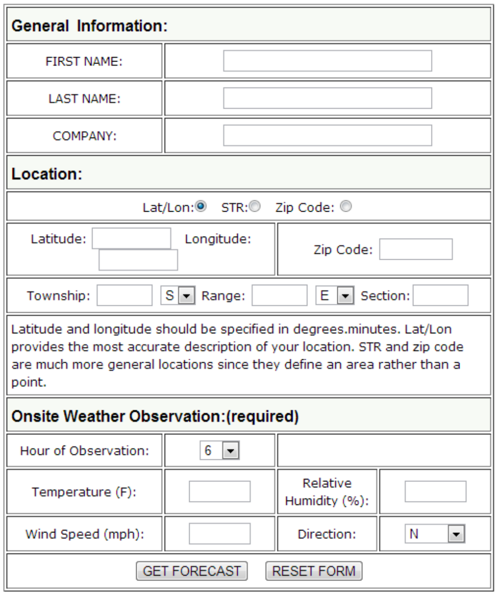


Figure A.2 Spot Weather Forecast Tool – inputs interface

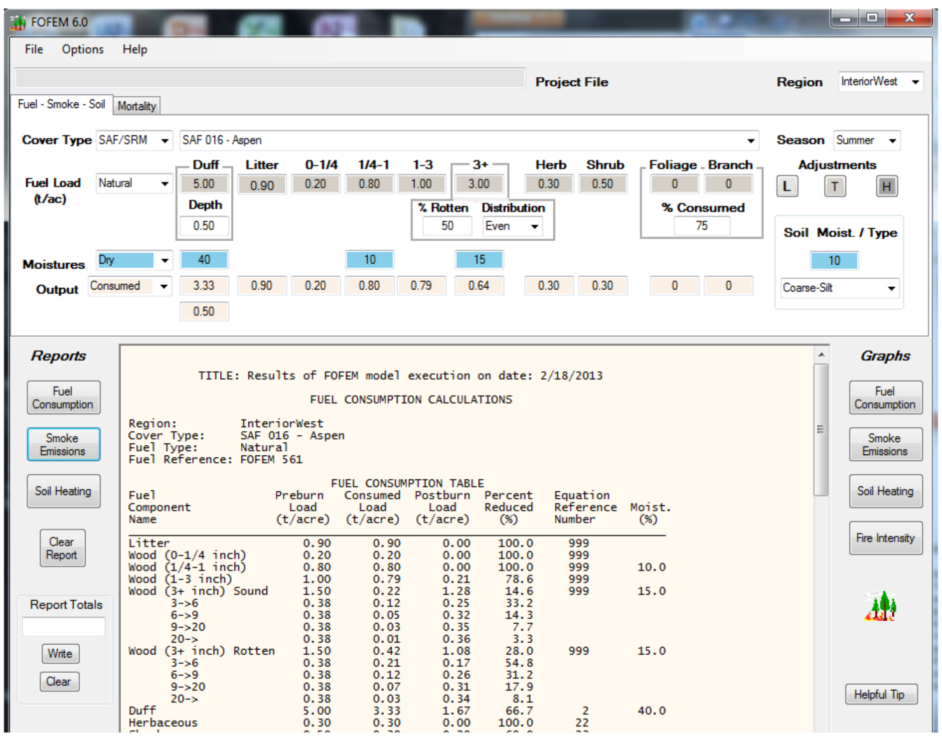


Figure A.3 First Order Fire Effects Model (FOFEM) – output interface

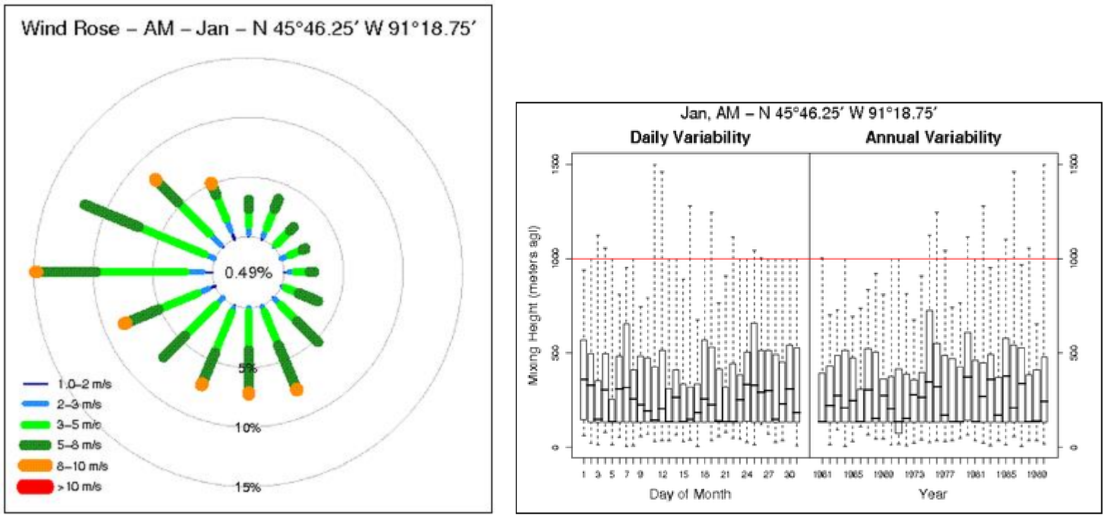


Figure A.4 Ventilation Climate Information System (VCIS)

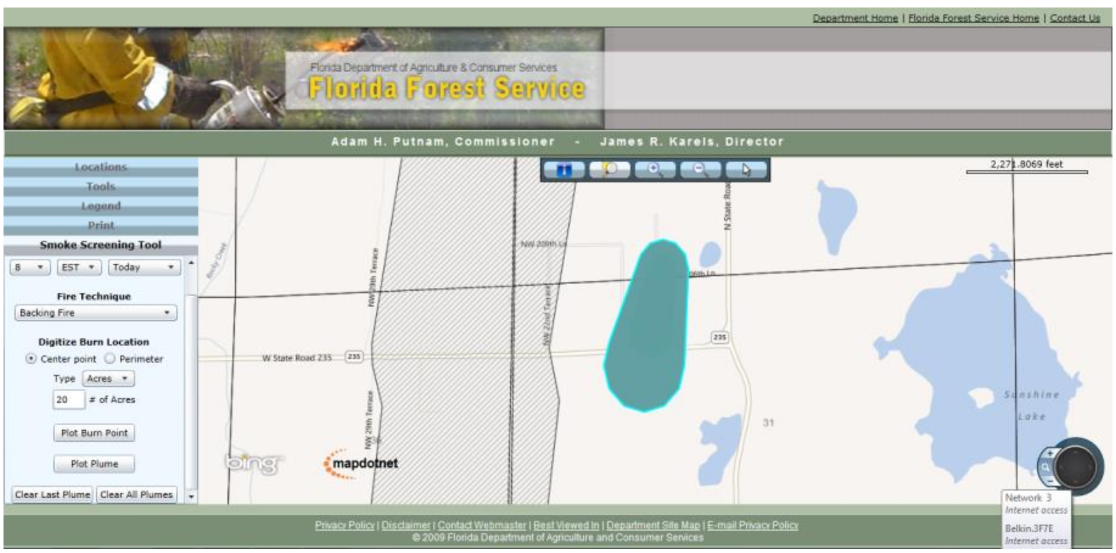


Figure A.5 Florida Forest Service Application

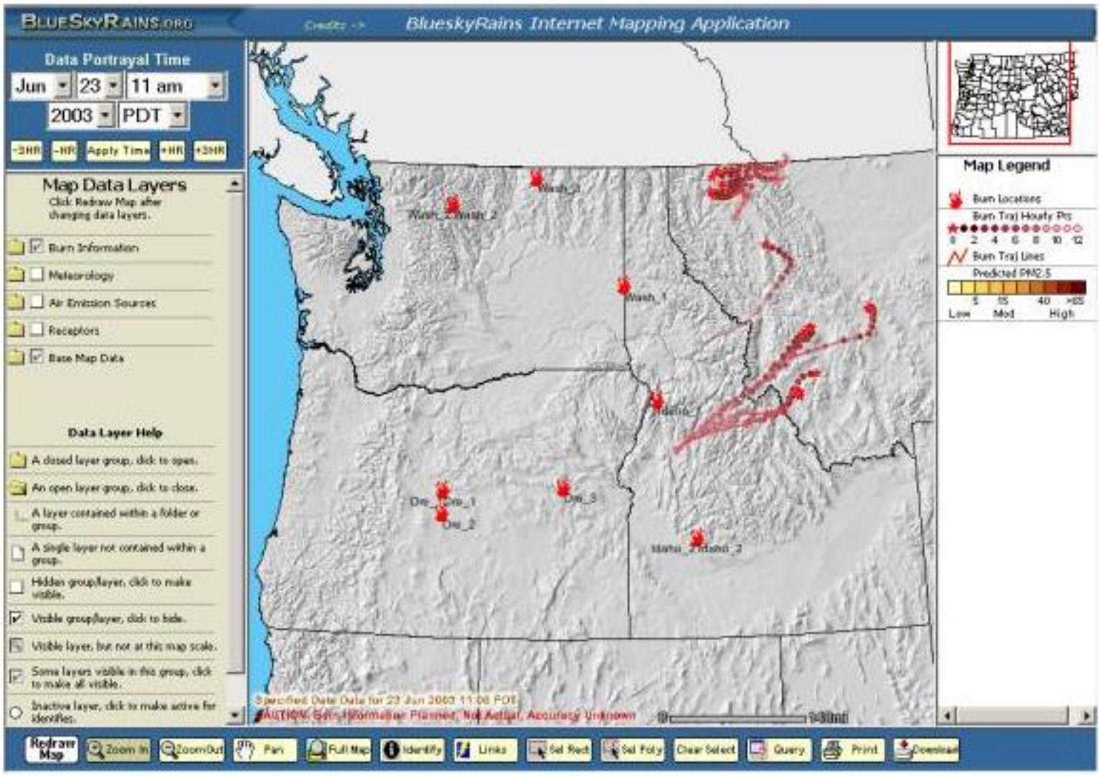


Figure A.6 Rapid Access Information System (RAINS) with BlueSky

Appendix B – SDLC Documents

Systems Overview

The LSU AgCenter plays a pivotal role in sugarcane burn smoke mitigation for the state of Louisiana. In collaboration with the Louisiana Department of Agriculture and Forestry, the LSU AgCenter had a hand in creating the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* and training program, which is a necessary component of the Louisiana sugarcane industry to remain compliant with federal law. Although participation in this program is voluntary, it is widely utilized by sugarcane farmers in the state to protect their own interests as well as their neighboring community. The currently used smoke management guidelines are taught as a manual process involving the look up of current weather variables, drawing a modeled smoke plume on a map, and physically writing the entire burn plan which is then stored as a record. The current system is easy to understand and is a great tool for estimating sugarcane burn impacts, but can be improved upon by translating it to digital form. By upgrading the process to an application format, current weather variables can be automatically pulled from the National Weather Service database, the smoke plume can be modeled and displayed on a digital map by the logic built in the application, and the burn plan can be printed or saved on a computer for more efficient and accurate record-keeping. The shift from a manual mitigation process to digital will theoretically reduce the time and effort required to complete a burn plan.

Known Issues List

- Drawing a model on a map is a very cumbersome task and is sometimes completed hastily or not at all.
- As a group, farmers are prone to rely on intuition gained from experiences, making a long mitigation process less likely to be used before burning sugarcane since it has been done many times before.
- Since Louisiana is the only U.S. state that does not have a *mandatory* smoke mitigation program it is important that volunteer numbers stay high by providing easy to use tools and very accessible resources.
- Paper record-keeping of the burn plans is unreliable.
- The smoke plume model is unsophisticated, relying on wind direction and wind speed only.
- There has not been an assessment of any kind of the currently used process

Risk Assessment

Risks arising from application development:

- Using new tools and learning new languages can slow down development speed.
- Working individually without a collaborator may exasperate coding challenges by not having a person to discuss the issues.
- “Feature creep”, or allowing additional features to be added while in development, can lengthen this stage and create timing problems.

Risks arising from the client:

- The LSU AgCenter is geographically far and all communications can only be done through email, Skype, or phone conversations.
- As the researcher and developer, I am beginning the project as someone unfamiliar with both Louisiana and the sugarcane industry. There is a risk

associated with being disconnected from the topic of study when developing for this specific population and surveying them as well.

- The potential users of the new application may prefer a manual process or be unwilling to change their current smoke mitigation habits.

Risks arising from the application:

- The first version, which only takes the current process and translates it to digital form, may not provide enough incentive for use.

- There may not be appropriate amount of time to build upon the first version and introduce more sophisticated components.

- The application does not store any data, except for what is saved to the personal computer of the user.

- Hosting an application online can never completely replace the manual process unless every member of that population has adequate Internet access.

- The application design will not be introduced to any members of the Louisiana sugarcane farming population until it is in its completed form. Even though it will be designed according to application design best practices, there may be issues with the look or feel of the application that deter its use.

Risks arising from the survey:

- Responses may be lower due to a large-scale survey distributed to the same pool of contacts by the LSU AgCenter as this survey, introducing the possibility of survey fatigue.

- All participants are pre-disposed to Internet access and use as the survey was distributed through email and taken online.

- The participants may not understand the purpose or importance of the survey.

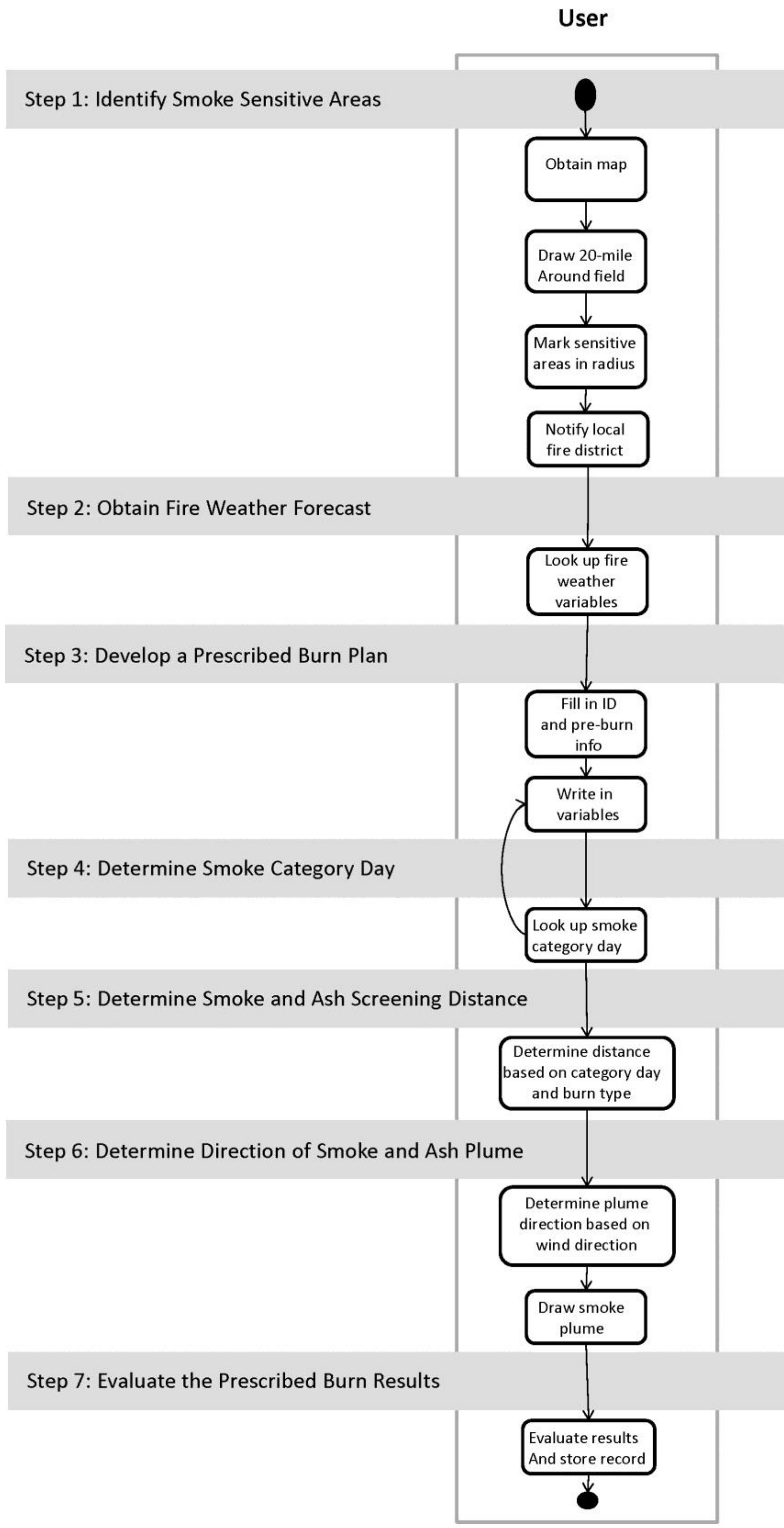
- The survey is moderately long, with 27 questions, and requires viewing a 4-minute video before beginning. The time requirement may be a detriment to survey participation.

- A low number of complete survey responses will limit the type of quantitative statistics I can to run.

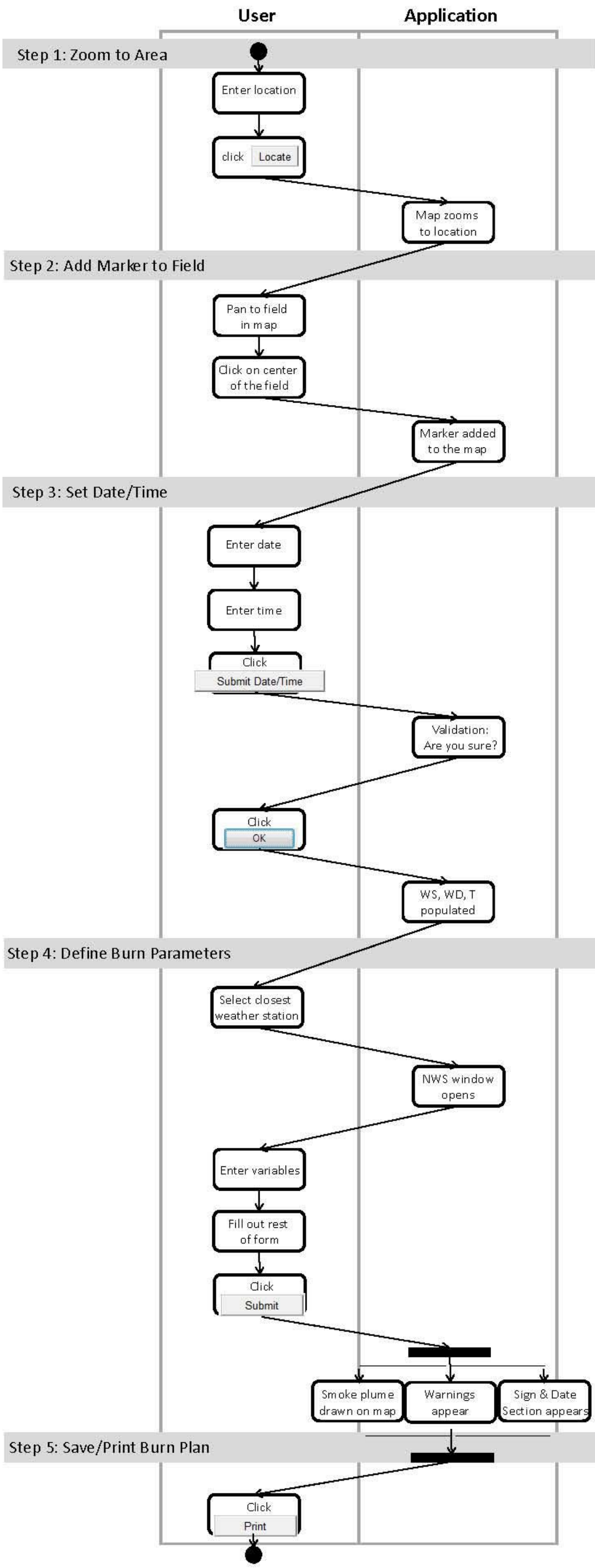
Interface Description

The application interface breaks up the original seven steps of the smoke plume mitigation process to five condensed steps. All five steps appear on one webpage, which simplifies the process when compared to the multiple-page website alternative. The screen is vertically split down the middle with the instructions and input boxes on the left and the interactive Google Maps API located on the right side, which can toggle between satellite view and map view to make finding the user's field easier. Links are provided for pop-up help explanations and the buttons run scripts that retrieve weather variables from the NWS server and model the smoke plume on the map. When the burn plan is submitted, warnings based on the indicated weather variables will appear below the map on the right-hand side. When the burn plan is completed, it is able to be printed or saved to the user's computer.

As-Is Process Flow



To-Be Process Flow



APPENDIX C – SURVEY

APPLICATION USABILITY

The questions in this section refer to the Sugarcane Burn Planner application demonstrated in the 4-minute video linked to in the email.

(1) If this application was available to you and was considered an adequate replacement to the paper burn plan, how would you use it?

◎ Instead of the paper burn plan
◎ In combination with the paper burn plan
◎ Would not use it

(2) Please indicate if you agree with the following statements:

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
This sugarcane burn planner will save me time	◎	◎	◎	◎	◎
This sugarcane burn planner is easy to use	◎	◎	◎	◎	◎
This sugarcane burn planner is intuitively designed	◎	◎	◎	◎	◎

(3) Please rate the usefulness of the following functions of the sugarcane burn planner:

	Very Useful	Useful	Moderately Useful	Of Little Usefulness	Useless
Automatically drawn smoke plume on map	◎	◎	◎	◎	◎
Automatic look-up of weather variables	◎	◎	◎	◎	◎
Printable burn plan	◎	◎	◎	◎	◎

(4) If made available, how likely are you to use this Internet-based Burn Planner in the future?

Very Likely	Likely	Moderately Likely	Not Very Likely	I would never use it
◎	◎	◎	◎	◎

(5) Please explain why you selected your ranking above (Are there functions/attributes missing? Do you think all the functions/attributes would be very useful?)

____

____

(6) Would you be interested in trying out this application when it is completed?

◎ Yes
◎ No

DEMOGRAPHIC INFORMATION

(7) In what year were you born? _____

(8) What is your final education level?

◎ Less than High School/GED
◎ High School/GED
◎ Some College
◎ Associate's Degree
◎ Bachelor's Degree
◎ Graduate Degree

(9) What is your farm address (or nearest address to sugarcane fields)?

____
____
____
____

(10) Do you have a farm decision-making role?

◎ Yes
◎ No

(11) If yes, what type of decisions are you responsible for?

____
____

(12) If yes, how many years have you been in this decision-making role?

◎ Less than 5 years
◎ 5 – 10 years
◎ 11 – 15 years
◎ 16 – 20 years
◎ More than 20 years

(13) How many years have you been in the sugarcane industry in any role?

◎ Less than 5 years
◎ 5 – 10 years
◎ 11 – 15 years
◎ 16 – 20 years
◎ More than 20 years

(14) On average, how many sugarcane burns do you conduct within one harvest season?

_____

(15) Approximately how many acres of sugarcane do you farm?

_____

TECHNOLOGY RESOURCES AND USE

(16) Do you have regular access to the Internet?

◎ Yes
◎ No

(17) How often do you use the Internet for the following purposes:

	Often	Sometimes	Seldom	Never
Entertainment/Social networking	◎	◎	◎	◎
Weather forecasts	◎	◎	◎	◎
Online banking	◎	◎	◎	◎
Information from research institutes	◎	◎	◎	◎
Look up input prices	◎	◎	◎	◎
Information on farming best practices	◎	◎	◎	◎
Recruitment of personnel	◎	◎	◎	◎
Information on new technologies	◎	◎	◎	◎
Mapping applications	◎	◎	◎	◎
Look up yield prices	◎	◎	◎	◎

(18) Overall, how important is the use of the Internet to save time or provide better information in regards to your farm practices?

Very Important	Important	Moderately Important	Of Little Importance	Unimportant
◎	◎	◎	◎	◎

(19) Please check all the device(s) that you own or have regular access to:

- ☐ Laptop computer
- ☐ Desktop computer
- ☐ Smartphone
- ☐ Tablet (iPad, Kindle, etc.)
- ☐ None of these

(20) Do you use a computer (e.g. laptop, smartphone, tablet) in the field?

◎ Yes
◎ No

COMMUNITY

(21) How close or far are your sugarcane fields from smoke sensitive areas (homes, schools, hospitals, etc.)?

◎ Very far (> 10 miles)
◎ Moderately far (5 to 10 miles)
◎ Fairly close (1 to 5 miles)
◎ Very close (< 1 mile)

(22) Approximately, how many people do you think are within a 5-mile radius of your burns?

______

(23) How many training sessions on the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* have you attended?

_____

(24) How long ago was the last time that you attended a training session?

◎ Less than six months ago
◎ Six months to 1 year ago
◎ 1 year to 5 years ago
◎ More than 5 years ago

(25) When completing a burn plan, how often do you complete the following sections of the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting*?

	Always	Usually	Sometimes	Never	N/A or Not familiar with this section
Step 1: Identify Areas Sensitive to Smoke and Ash	◎	◎	◎	◎	◎
Step 2: Obtain Fire Weather Forecast	◎	◎	◎	◎	◎
Step 3: Develop a Prescribed Burn Plan	◎	◎	◎	◎	◎
Step 4: Determine Smoke Category Day	◎	◎	◎	◎	◎
Step 5: Determine Smoke and Ash Screening Distance	◎	◎	◎	◎	◎
Step 6: Determine Trajectory of Smoke and Ash Plume	◎	◎	◎	◎	◎
Step 7: Evaluate the Prescribed Burn Results	◎	◎	◎	◎	◎

(26) How effective are the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* in helping you plan when to burn?

◎ Very Effective
◎ Effective
◎ Moderately Effective
◎ Of Little Effectiveness
◎ Uneffective
◎ I'm not familiar with these guidelines

(27) How important is the use of the *Louisiana Smoke Management Guidelines for Sugarcane Harvesting* by sugarcane farmers?

◎ Very Important
◎ Important
◎ Moderately Important
◎ Of Little Importance
◎ Unimportant
◎ I'm not familiar with these guidelines

APPENDIX D – STATISTICALLY SIGNIFICANT CORRELATIONS

Table D.1 Significant Correlations with Likelihood of Use (Q4)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q2	Will Save Time	SR	0.001	0.703
Q2	Is Easy to Use	SR	0.011	0.553
Q2	Is Intuitive Design	SR	0.005	0.601
Q3	Auto Weather Variables	SR	0.045	0.454
Q3	Drawn Smoke Plume	SR	0.002	0.654
Q17	Info from Research Institutes	SR	0.023	0.506
Q17	Info on Farm Best Practices	SR	0.002	0.661
Q17	Info on New Farm Technologies	SR	0.007	0.586
Q17	Mapping Applications	SR	0.017	0.528
Q17	Look up Yield Prices	SR	0.013	0.545
Q23	No. of Training Sessions	SR	0.042	-0.531

Table D.2 Significant Correlations with Application will Save Time (Q2)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q2	Is Easy to Use	SR	0.037	0.468
Q17	Info on Farm Best Practices	SR	0.044	0.454
Q17	Info on New Farm Technologies	SR	0.037	0.468
Q22	Perceived Distance from Sensitive Sites (In # of People Affected)	SR	0.021	0.629

Table D.3 Significant Correlations with Application is Easy to Use (Q2)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q1	Adoptability (Type of Use)	KW	0.027	0.486
Q2	Is Intuitively Designed	SR	0	0.754
Q17	Weather Forecasts	SR	0.02	0.515
Q17	Info from Research Institutes	SR	0.001	0.69
Q17	Info on Farm Best Practices	SR	0.001	0.682
Q17	Info on New Farm Technologies	SR	0	0.732
Q17	Mapping Applications	SR	0.005	0.602
Q17	Look up of Yield Prices	SR	0	0.734
Q18	Internet Importance	SR	0.013	0.564
Q19	Device Ownership	SR	0.008	0.586

Table D.4 Significant Correlations with Application is Intuitively Designed (Q2)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q12	Farming Experience (Years in Role)	KW	0.044	11.381
Q17	Info from Research Institutes	SR	0.01	0.56
Q17	Info on Farm Best Practices	SR	0.015	0.537
Q17	Info on New Farm Technologies	SR	0.005	0.599
Q17	Look up of Yield Prices	SR	0.003	0.628
Q18	Internet Importance	SR	0.033	0.478
Q19	Device Ownership	SR	0.032	0.492
Q26	Program Evaluation (Effectiveness)	SR	0.043	0.456
Q27	Program Evaluation (Importance)	SR	0.037	0.469

Table D.5 Significant Correlations with Usefulness of Drawn Plume (Q3)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q23	Training Sessions (# Attended)	SR	0.005	0.683

Table D.6 Significant Correlations with Usefulness of Printable Burn Plan (Q3)

Survey Question	Variable Name	Statistical Test	p-Value	Coefficient
Q21	Perceived Distance from Sensitive Sites (in miles)	KW	0.049	6.016
Q19	Device Ownership	SR	0.001	0.676